TEXT BOUND INTO THE SPINE
BEST COPY AVAILABLE

Variable print quality
FIGURATIVE LANGUAGE: AN INVESTIGATION OF ITS VALUE IN THE TEACHING AND LEARNING OF CHEMISTRY

Pamela M. Denicolo

In partial fulfilment of the requirements for the degree of Doctor of Philosophy, University of Surrey, April 1985.
TO VINCENT

WITH ALL MY LOVE
ACKNOWLEDGEMENTS

I would like to express my heartfelt thanks to the following:—
Dr Maureen Pope and Dr John Gilbert, who sowed the original seed and provided the rain, sun and judicious pruning in the right seasons;
my many friends and colleagues in the department, who provided a warm environment and essential nutrients;
Vonney, who laboured into the night with her processing machine to put everything into neat rows;
the teachers and students in my study, whose own growth provided inspiration;
my Mum and my friends, Betty and Kathleen, who provided unfailing encouragement and who quietly kept the weeds down around me;
Marie-Anne and Paul, who grew and blossomed without stunting my growth;
Vincent, whose strong support and loving care gave me room to grow.

There would be no fruit without them.
SUMMARY

The general area of concern of this study is how explanations are given and received in science lessons. The particular focus of attention of the research is on the use of figurative language in explanation in chemistry lessons.

The study begins with a review of the literature which indicates that various theoretical perspectives exist about the value of figurative language in general discourse, in science and in explanations in education. This provides the rationale for an empirical investigation of some particular relevant questions which are refined by consideration of current theories in the psychology of education.

This is followed by the consideration of an appropriate methodology for the investigation and a description of the practical application of the chosen research methods.

Five classes were studied in depth, these being presented as two full case studies and three summary case studies.

Coordination of the data derived from these studies provides some answers to the original research questions, provides some practical suggestions to teachers about modes of explanation and also uncovers other questions for further research.
The implications and consequences of the chosen methodology are discussed, as is the relationship between the results of the research and the findings of the preceding literature review.

The study then concludes with a discussion of the implications of the research findings for teacher training, student learning and for future research.
# CONTENTS

## CHAPTER 1 - FIGURATIVE LANGUAGE - A MODE OF EXPLANATION IN SCIENCE

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
<td>1</td>
</tr>
<tr>
<td>1.1</td>
<td>2</td>
</tr>
<tr>
<td>1.2</td>
<td>3</td>
</tr>
<tr>
<td>1.3</td>
<td>6</td>
</tr>
<tr>
<td>1.4</td>
<td>8</td>
</tr>
<tr>
<td>1.5</td>
<td>12</td>
</tr>
<tr>
<td>1.6</td>
<td>18</td>
</tr>
</tbody>
</table>

## CHAPTER 2 - RESEARCH QUESTIONS

## CHAPTER 3 - METHODOLOGY

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.1</td>
<td>25</td>
</tr>
<tr>
<td>3.2</td>
<td>34</td>
</tr>
</tbody>
</table>

## CHAPTER 4 - METHOD AND PROCEDURE

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.1</td>
<td>53</td>
</tr>
<tr>
<td>4.2</td>
<td>58</td>
</tr>
<tr>
<td>4.3</td>
<td>61</td>
</tr>
<tr>
<td>4.4</td>
<td>68</td>
</tr>
</tbody>
</table>

## CHAPTER 5 - CASE STUDY 1

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.1.1. General Background.</td>
<td>74</td>
</tr>
<tr>
<td>5.1.2. Temporal Sequence of Study.</td>
<td>75</td>
</tr>
<tr>
<td>5.1.3. Locations of Fieldwork Components.</td>
<td>77</td>
</tr>
<tr>
<td>5.1.4. Participants.</td>
<td>78</td>
</tr>
<tr>
<td>5.1.5. Fieldwork Experiences which Affect Analysis of Data.</td>
<td>78</td>
</tr>
<tr>
<td>5.2.1. Data from Classroom Observations.</td>
<td>82</td>
</tr>
<tr>
<td>5.2.2. Interpretation of Data from Classroom Observations.</td>
<td>86</td>
</tr>
<tr>
<td>5.2.3. Analysis and Interpretation of Grids.</td>
<td>89</td>
</tr>
<tr>
<td>5.2.4. Data and Interpretation from Interviews and Grid Discussion.</td>
<td>96</td>
</tr>
<tr>
<td>5.3.1. Student Interview and Workshop, General Points.</td>
<td>118</td>
</tr>
<tr>
<td>5.3.2. Individual Student Responses.</td>
<td>119</td>
</tr>
<tr>
<td>5.3.3. General Results of Analysis of Student Interview Data.</td>
<td>147</td>
</tr>
<tr>
<td>5.3.4. Student Workshop Data and Interpretation.</td>
<td>150</td>
</tr>
<tr>
<td>5.4. Coordination of Interpretations from Case Study 1.</td>
<td>160</td>
</tr>
</tbody>
</table>
CHAPTER 6 - CASE STUDY 2.

6.1.1. General Background. 166
6.1.2. Temporal Sequence of Study. 166
6.1.3. Location of Fieldwork Components. 167
6.1.4. Participants. 167
6.1.5. Fieldwork Experiences which Affect Analysis of Data. 168

6.2.1. Data and Interpretation of Classroom Observations. 169
6.2.2. Analysis and Interpretation of Grids. 173
6.2.3. Data and Interpretation from Interviews. 182

6.3.1. Student Interviews and Workshop - General Points. 194
6.3.2. Individual Student Responses. 195
6.3.3. General Results of Analysis of Student Interview Data. 204
6.3.4. Student Workshop Data and Interpretation. 207

6.4 Coordination of Interpretations from Case Study 2. 216

CHAPTER 7 - SUMMARY OF DATA FROM OTHER CLASSES STUDIED

7.1. Introduction. 220
7.2. CLASS SUMMARY I
  7.2.1. School Description. 221
  7.2.2. Class Description. 221
  7.2.3. Data Collection. 222
  7.2.4. Teacher Description. 223
  7.2.5. Data Interpretation. 223
  7.2.6. Coordination of Data. 232
7.3. CLASS SUMMARY II
  7.3.1. School Description. 234
  7.3.2. Class Description. 235
  7.3.3. Data Collection. 235
  7.3.4. Teacher Description. 236
  7.3.5. Data Interpretation. 236
  7.3.6. Coordination of Data. 250
7.4. CLASS SUMMARY III
  7.4.1. School Description. 252
  7.4.2. Class Description. 253
  7.4.3. Data Collection. 253
  7.4.4. Teacher Description. 254
  7.4.5. Data Interpretation. 254
  7.4.6. Coordination of Data. 261

CHAPTER 8 - COORDINATION OF RESEARCH DATA AND RESULTS.

8.1.0. COORDINATION OF ALL TEACHER DATA.
  8.1.1. Description of Data Coordination. 263
8.1.2. Patterns Found and Questions Answered. 265
8.2.0. COORDINATION OF ALL STUDENT DATA.
  8.2.1. Description of Data Coordination. 269
8.2.2. Patterns Found and Questions Answered. 273
8.3.0. COORDINATION OF DATA FROM ALL CLASSES (TEACHERS AND OWN STUDENTS)
8.3.1. Description of Data Coordination. 275
8.3.2. Patterns Found and Questions Answered. 277
8.4. PRACTICAL CONSIDERATIONS AND SUGGESTIONS FOR TEACHERS. 282

CHAPTER 9 - DISCUSSION

9.1.0. IMPLICATIONS AND CONSEQUENCES OF THE RESEARCH METHODOLOGY.
9.1.1. Particular Methods Used. 286
9.1.2. The Combination of Methods. 292
9.2. Research Results in Relation to the Literature Review. 298
9.3. Implications for Teacher Training and H.E. Student Learning. 301
9.4. Implications for Future Research. 303
9.5. This Pilgrim's Progress. 304

APPENDIX I - Letter to Headmasters.

APPENDIX IIa - C.S.1. Preliminary Analysis of Lesson.
IIb - C.S.1. Sample of Lesson Transcript.
IIc - C.S.1. Plot of Sample Lesson.
IID - C.S.1. Samples of Student Written Data from Workshop.

APPENDIX IIIa - C.S.2. Preliminary Analysis of Lesson.
IIIb - C.S.2. Sample of Lesson Transcript.
IIIc - C.S.2. Plot of Sample Lesson.
IIIId - C.S.2. Samples of Student Written Data from Workshop.

APPENDIX IV - Table II - Summary of Student Interview Data.
CHAPTER 1

FIGURATIVE LANGUAGE - A MODE OF EXPLANATION IN SCIENCE
CHAPTER 1. FIGURATIVE LANGUAGE - A MODE OF EXPLANATION IN SCIENCE

1.0. INTRODUCTION

This thesis examines figurative language as a possible mode of explanation in science, the teaching and learning of chemistry being the particular focus.

The first chapter seeks to give context to the empirical work of later chapters by noting the importance of explanation in education (1.1) and defining figurative language, and noting references to its use as a form of explanation (1.2).

This is followed by a review of the literature concerning the form and function of figurative language in general discourse (1.3), in science (1.4) and in teaching and learning (1.5). Finally, these presented views are summarised to provide the rationale for the particular area of investigation (1.6)
1.1 EXPLANATION IN EDUCATION

A challenge was laid down to those involved in education and its research by the Bullock report (1974):

'We must convince the teacher of history and science, for example, that he has to understand the process by which his pupils take possession of the historical and scientific information that is offered them; and that such an understanding involves his paying attention to the part language plays in learning'.

A particular concern with language, the way in which explanations are couched, has been expressed by a chemistry teacher:

'Unless we use teaching strategies which give our pupils ample opportunity to make what we teach a part of themselves then we are in danger of fostering the idea that "schooling is concerned with the regurgitation of someone else's ideas in someone else's language"'.

CASSELS 1980 p. 24

The prominence of explanation, being 'at the heart of teaching...... and at the heart of learning' is also demonstrated by George Brown in 'Lecturing and Explaining' (1978) in which he delineates its inherent pragmatic problems.

Gage also addresses explanation, noting some of its problem areas:

'Some people explain aptly, getting to the heart of the matter with just the right terminology, examples and organisation of ideas. Others get us and themselves all mixed up, use terms beyond our level of comprehension, draw inept analogies, and even employ concepts and principles that cannot be understood without an understanding of the very thing being explained.'

GAGE 1972
These views suggest that a study of some aspects of the art of explanation in the science of chemistry is of interest and value to those involved in the processes of its teaching and learning.

1.2 FIGURATIVE LANGUAGE - A FORM OF EXPLANATION

During the course of a literature search into explanatory language and science education a recurrent theme emerged. Frequent mention was made of metaphor, simile, analogy, personification and theoretical or hypothetical models. For the purposes of this thesis these will be subsumed under the term figurative language which denotes that one thing is explained by highlighting its resemblance to something else in some way, its sense being transferred from the literal to the hypothetical.

There are both theoretical and pragmatic reasons for the use of this more general term. Firstly, Leatherdale (1974) noted that metaphor and analogy are sometimes used as if they were synonymous terms and, further that the concepts of metaphor and model both include within their sense the concept of analogy. It is Black's (1962) view that metaphor is not a matter of syntax but is initially concerned with semantics, i.e. meanings, and pragmatics, i.e. actual language use:

"(Metaphor) is a loose word, at best, and we must beware of attributing to it stricter rules of usage than are usually found in practice"

BLACK 1962 p. 25
To illustrate his problem of being unable to find a necessary and sufficient condition for defining a piece of language as metaphor he refers to Wittgenstein's (1953) discussion of 'the game', another concept which is identified by usage rather than by an identifiable set of characteristics.

Sampson (1980) goes further in stating that even the bounds between figurative language and literal language are ill-defined. He points to a plethora of words which were originally metaphorical, e.g. 'crooked' for dishonest, but which are in such common usage that they might now be accepted as literal. These are sometimes termed 'frozen' metaphors. Pollio et al (1977) counted the use of frozen and novel metaphors in a wide variety of contexts distinguishing the high average frequencies of three 'frozen' metaphors per hundred words and one and a half novel metaphors per hundred words. However, their discussion centred not on evaluation of their use but on the difficulties of achieving agreement on metaphor identification.

Additional justification for the study of figurative language in a general rather than a particular form comes from the observation that teachers may use several forms of syntax in their spoken lessons, each linking one concept to another by way of simile, analogy or metaphor e.g. 'electrons orbiting like planets'; 'as the sun is to its planets so is the nucleus to its electrons;' 'the atom is a solar system.' "Further there" are occasions in studying spoken language when it is difficult to
distinguish which figure of speech is being employed since speech does not always conform to the grammatical rules of syntax expected in the written form.

Three particular perspectives on the use of figurative language forms in explanation which indicate a spread of interest are presented by:—

a scientist —

'Even analysis, even the ability to plan experiments, even the ability to sort out and pick them apart presupposes a good deal of structure, and that structure is characteristically an analogical one'

OPPENHEIMER 1956 p. 134

a philosopher of science —

'metaphor plays an essential role in establishing links between scientific language and the world.

KUHN 1979 p. 414/15

a researcher in science education —

'When teachers use similes and analogies they are frequently searching for a simple way of putting a complex or abstract idea, helping the learner to visualise it in such a way that they can examine the implications for themselves.'

SUTTON 1981 p.219

Similarly, following an in-depth investigation into general language use in the classroom, Richards (1978) advocated that classroom explanations of abstract phenomena should take the form of analogy with everyday phenomena within the children's conceptual range. She also thought that 'exploratory' talk, in which children describe observations in their own terms should be encouraged. This may be linked with Barnes' (1972) notion that the act of verbalising new knowledge often involves the
This initial examination of the literature suggests that a more comprehensive survey would be appropriate, looking firstly at the place of figurative language in general discourse, then at perspectives on its use in science, with a final survey of opinions of its value in teaching and learning.

1.3. THE FORM AND FUNCTION OF FIGURATIVE LANGUAGE IN GENERAL DISCOURSE

The difficulty of identifying forms of figurative language mentioned in the previous section may derive, at least in part, from the way in which metaphor comes to be a part of language. Schon (1967) reviewed some of the then current theories of metaphor and language: that metaphor is a principle of growth in language, that it is a primitive state of language and that all language is metaphorical. His discussion includes the work of Richards (1936), Brown (1958), Cassirer (1946) and Fromm (1951). His main conclusion was not that any of these viewpoints was more valid than the others but that the possibilities that they raise as a group support the notion of a complex relationship between language and thought or conception formation.

Themes similar to those found in Schon's (1967) work can also be identified in the writings of other authors: Hesse (1966) suggests that metaphor is one of the chief means of continuously adapting our language to a continually expanding world; Sutton (1981) describes how metaphor may be born out of peoples
struggles to understand; Rumelhart (1973) sees metaphor as playing a crucial part in language acquisition where children apply words which they have learnt in one context to other contexts which seem appropriate to them, even though it may be unconventional usage from the adult viewpoint.

The theme of a link between language and conceptualisation is also found in Lakoff (1980). He goes into greater depth of discussion and uses a wealth of examples to illustrate how metaphors rooted in physical and cultural experience help us to understand the world about us. He discusses, for instance, how by treating abstract ideas (e.g. feelings or electrons) or non-human physical entities (e.g. mountains or street corners) as bounded, discrete objects like ourselves we can refer to them, categorise them, group them and quantify them. Lakoff's account is based on his formulation that most of our concepts are understood in terms of other concepts - typically we conceptualise the non-physical in terms of the physical, the less clearly delineated in terms of the more clearly delineated. This has much in common with Kelly's notion of the contrasts inherent in construing (described in Bannister and Fransella, 1971).

While Lakoff suggests that if a new metaphor enters the conceptual system on which we base our actions, it will alter that concept system and along with it the perceptions and actions that it gives rise to, so does Kelly propose a similar set of entailments when a new construct enters the construct system.
The main thrust of these arguments is that metaphor, and its language relations, plays a crucial role in our general understanding of the world and in our sharing of that understanding with others.

1.4. FIGURATIVE LANGUAGE IN SCIENCE

In this section some historical perspectives on the use of figurative language in the particular field of science are contrasted with some more modern views on its use and relevance to that area of knowledge.

In the past, many writers have decried the use of figurative language in the realm of logical or scientific discourse. Both Lakoff (1980) and Schon noted this reticence in writers from the past, citing Aristotle who urged wariness in relation to the ambiguity and obscurity inherent in definitions using metaphor.

This view also pervades the rationalist school of thought exemplified by Hobbes (see Burtt 1939), who feared that the confusion that metaphor engenders (because of its illogical nature) would let chaos into scientific reasoning.

In Duhem's (1914) analysis, in which he objects to most models and analogies in science as being distractors from the search for
logical order, metaphor appears as representative of the 'visualising, imaginative and incoherent mind.'

A similar view is supported by the logical positivist school in their faith that literal language is the only adequate tool for the objective characterisation of reality (Ortony, 1979) and who, as empiricists, fear the subjectivity inherent in figurative language (Lakoff 1980).

Black (1962) while not denying that some metaphors fit the comparison theory of metaphor in that the comparison could be made alternatively in literal language, points out that often a literal equivalent would be extremely long-winded or vague. Other metaphors, which he describes as 'non-trivial' would better fit the interactive theory of metaphor. He sees this kind of metaphor as creating similarity by the interaction of two thoughts rather than merely formulating similarity which exists antecedently. This has much in common with Schon's (1976) 'generative theory', Cassirer's (1949) 'radical metaphor' and Boyd's (Ortony 1979) 'theory - constitutive metaphor'.

For Black (op. cit.) metaphor may sometimes also be seen as a species of catachresis, not only stimulating thought by paradox but also necessary when a literal equivalent is not available.

"We need metaphors in just the cases when there can be no question as yet of the precision of scientific statement" BLACK 1962 p. 37
Lakoff (1980) takes up the subjectivity objection by producing an argument that metaphor unites reason and imagination to produce 'imaginative rationality' since both reason and metaphor involve some form of categorisation, entailment and inference and both imagination and metaphor involve seeing one kind of thing in terms of another kind of thing. With this approach he hopes to bridge the gap between the objectivist and subjectivist viewpoints rather than to suggest that metaphor is more truly a tool of either.

Hesse (1966) follows a similar argument in her justification of the use of models and analogies in science by saying that intelligible interpretation of theories takes place via those methods and further, that without them, extensions to theory would be merely arbitrary so that predictions in new domains of the phenomena would be a difficult if not impossible task. Boyd (1979) also sees the theory-constitutive metaphor as an invitation to future research since its function is to put us on the track of relevant similarities which may not yet be known.

This point is reiterated by Schon who counters the argument that metaphors used in science, such as 'the genetic code', 'atomic wind', 'the brain as a telephone exchange' and Bruner's 'economic choice in concept formation', simply reflect the ways of teaching and explaining theories by referring to the external evidence provided by accounts of the development of these theories from metaphors and analogies by those who participated (e.g. 'The Double Helix' by Watson and Crick 1968).
Gallagher (1978) agrees that metaphors and analogies supply a powerful and creative framework for scientific exploration while Sutton (1981) contends that they are epistemologically necessary when scientists struggle to make sense of some matter - metaphors present themselves as insights to the mind which tease it into action to explore the possibilities that the juxtaposition has illuminated:

'Sir Peter Medawar describes science as a system of guesswork and checkwork. Metaphor initiates the guesswork. Scientists believe they have a method for controlling its wildest excesses by the checkwork of empirical tests'.

SUTTON 1981 p.219

If the 'flash of insight' produces a model which is simple, has wide explanatory power, internal consistency and the ability to generate testable predictions then, Sutton proposes, it will become 'not just a useful idea but a description of reality'. He illustrates this by noting that although Dalton originally put forward the atomic theory in an 'as if' spirit, most science teachers would find it difficult to think of atoms as anything but REAL.

In summary, although there is a history of views which would describe figurative language as detrimental to exposition in contexts such as the scientific field where precision of discourse is deemed important, more recent writers have proposed various benefits of this form of language use ranging from description of new concepts when a literal form is not available through extension of concepts to the creating of new concepts.
In this section a review of the various benefits of figurative language in the educational context will be presented, followed by some of the limitations of it which have been proposed.

Several writers see this form of language as useful for developing thought and aiding concept formation e.g. Petrie (1979) describes the interactive metaphor as creating anomaly which then leads to changes in cognitive structure and he compares this idea to Kuhn's (1970) description of the workings of science during scientific revolutions. The essence of this idea is also reflected in Gallagher's (1978) comparison of the adolescents understanding of metaphor with Piaget's (1977) newly emphasized system of correspondence:

'Mental activity in a Piagetian sense, is viewed as relational when each new understanding is connected logically in a more complex way to an earlier understanding. Therefore, in both thought and action, the growth mechanism in knowledge must be considered both retrospective and drawing upon previous sources for its elements, and constructive, inventing new relationships'.

GALLAGHER 1978 p.79

In his book 'Invention and Evolution of Ideas', Schon (1967) gives a central place to metaphor and analogy in concept formation in that they aid the displacement of already learned concepts into situations outside their normal pattern of use. He suggest that the juxtaposition provided by the metaphor acts as a prelude to concept formation by extending the original ideas to
new instances, transforming them in the process:

'The new concept grows out of the making, elaboration and correction of the metaphor'.

He, himself, uses an evolutionary metaphor to describe the emergence of new concepts and considers the idea that the metaphorical character of language can be explained as signs of concepts at various stages of evolution.

Certainly these theorists would seem to agree with Tourangeau and Sternberg (1981) that metaphors 'jolt us out of the usual way of thinking'.

A further variety of functions are attributed to figurative language by other writers:

Gallagher (1978 p. 87) proposes that:

'the use of analogies, particularly with metaphor, adds richness and dimension to arguments and descriptions not possible with ordinary discourse or with propositional reasoning'.

Billow (1975) in a study of understanding of metaphor with and without pictorial accompaniment, found that they are in general highly image-provoking in their own right and it is this aspect which appeals to Sutton (1981) who illustrates this by quoting Rutherford's reaction in his experiment involving firing alpha particles at gold foil:

'It was as if you had fired a 15 inch shell at a piece of paper, and it had come back and hit you'.

13
The implication that imagery plays a central role in understanding via metaphor is emphasized also in Paivio's account:

'The pairing of two images throws into relief a common quality and thereby accomplishes a perceptual abstraction without relinquishing the context from which the singled-out quality draws life'.

In ORTONY 1979 p. 156

In an earlier work, Paivio (1969) had also noted the importance of imageability for retention in memory.

Sticht (1979) sees metaphor as sometimes helpful, though not always necessary, in extending capacities for communication. He compares the tool function of the telescope to extend the eye with metaphor being used to extend the capacity of active memory using the medium of speech.

Elements of these issues can be found in the three ways that Ortony (1975) suggest that metaphors facilitate learning:

a) the compactness thesis (transference of chunks of experience from the well-known to the less well-known);

b) the vividness thesis (the production of greater imagery);

c) the unexpressibility thesis (some metaphors carry extra meaning that can never be encoded in language).

The last thesis, like Blacks interactive theory, suggests an extension of meaning beyond that which is first apparent — what Berggren (1982) calls its 'uniquely revelatory function'.
Similarly Black (1962) emphasizes that metaphor affords us a different way of perceiving which may involve a shift in the meaning of words. He proposes a 'filter theory' whereby the principle subject is 'seen through' the metaphorical expression, something new being created in the process. Ortony (1975), in a similar vein, notes that the study of cognition involves perception, memory and language, each intimately related so that cognition is a result of mental construction or 'going beyond what is given.'

Petrie (1974) sees as an important point the ability of metaphor to transfer learning from the well-known to the less well-known. Similarly, Miller (1979) sees it as maximising the use of what is already known while Lakoff (1980) points out that it is a way of focussing our attention on particular aspects of complex phenomena.

However, other writers have stressed that this is not merely a facilitative ability: as Stanford (1936 p. 105) puts it:

'it requires "stereoscopic vision"; the ability to entertain two different points of view at the same time'

Further Cassirer (1946) notes that it requires not the mere transference of an object from one category to another but the creation of a new category. Schon (1967) illustrates his assertion that it requires intelligent use of the old in the new by the use of the Epaminondas story (p. 22 et seq.) where a young boy used 'old learning' punctiliously in a new but similar situation thereby failing to take account of the novel and different properties in that situation.
In proposing a 'tensive' use of metaphor, emphasizing the conceptual incompatibility of its terms, Richards (1936) notes that two ideas may interact to produce a new resultant idea only if a full account is taken of both ideas, their interrelations and their relations to the 'metaphoric tension' produced by the conjoining of two statements which are apparently self-contradictory or absurd. He states that some principle of assimilation must be found to link the two referents.

Similarly, Pylyshyn (1979) stresses that the careless use of metaphor can do more harm than good because those which are descriptive but contain no element of explanation can leave the learner with the unjustified feeling that they have understood the problem. He says of this type of metaphor:

'But that the accounts come to REST on it because of its subjective comfort IS to my mind a more serious problem'.

There is also the problem, inherent in both structural and linguistic models, that the similarities are accentuated at the expense of the dissimilarities. Miller (1979) states:

'A distinction between what is 'true-in-fact' and "true-in-the-model" must be included in any general theory of textual comprehension'.

Features which to the teacher may seem patently non-analogous between the principle and subsidiary subject (or vehicle and tenor as some writers prefer) may not necessarily seem so to the learner. Pimm (1980) in his study of metaphor in mathematics,
finds that sometimes:

'Metaphors deny distinctions between things; problems often arise from taking metaphors too literally'.

Tourangeau and Sternberg's (1981) work on mapping constructs in space finds that comprehension is easier if the 'within-subspace' and 'between-subspace' distances between tenor and vehicle are small, although this may be less aesthetically pleasing than when 'between-subspace' distances are large. They suggest that students may require smaller 'between-subspace' differences than the teacher in order to understand his/her metaphors.

Supporting this view, Sticht (1979) advises that when teachers use metaphors as efficient tools of communication, it is not advisable that they produce too much puzzlement in the minds of the students. He also stresses a point which recurs in the literature i.e. that the effective use of metaphor requires the teacher to know that the students possess the knowledge addressed in the metaphor. In order for learning to be transferred to the less well-known concept from the well-known concept, both the user and the receiver of the metaphor should have a common understanding of the latter concept.

In summary, then, it would seem from the foregoing comments that teachers would have to give some consideration to what the actual use of figurative language involves for their own devising of it and for those receiving it as a form of explanation before using it to achieve the large number of benefits proposed at the beginning of this section.
SUMMARY OF LITERATURE SEARCH: RATIONALE FOR THE EMPIRICAL INVESTIGATION.

This review of the literature reveals a continuum of perspectives on figurative language. At one extreme are those who view figurative language as a general bar to effective communication, perhaps not of beauty and emotion but certainly of logic and science, while at the other extreme are those who see it as the only way we have of understanding experience and communicating it to others, of developing hypotheses and of extending theories.

Similarly, in the particular realm of education, there are those who stress the possibility of engendering confusion by the use of such language per se or by employing a counter-productive mode of its use. Conversely, others are convinced of its heuristic value or are impressed by its ability to link new understandings to old, so to aid imagery and memory.

With few exceptions, these various arguments are not based on empirical research but are the product of reasoning, either inferential or deductive. As such, they represent the personal viewpoints of theorists made in their individual contexts which are mainly theoretical.

A perspective which appears to be missing is the one of the participants involved in the practical part of education - those who have to devise or interpret explanations.
The need for empirical research in this area is elaborated on in Pope and Gilbert's (1983) paper 'Explanations and Metaphor: some empirical questions'. Briefly this addresses the need to discover how and why different teachers might use metaphor and how such explanations are received in particular contexts by different students.

It is proposed that this research should attempt to investigate this missing perspective and address some of the problems raised by these questions by refining some questions as they pertain to a particular context and by designing and implementing a study to answer them.
CHAPTER 2

RESEARCH QUESTIONS
CHAPTER 2.

RESEARCH QUESTIONS

Given the debate in the literature about the appropriateness or otherwise of the use of figurative language in science, the first general objective of an empirical quest would be to discover if metaphor, analogy etc., are used in practice in science classrooms and, if so, which ones are used, for what purpose and to what effect.

To further define the area of study, the general context must be considered i.e. the focus will be on an interaction between teachers and learners, each with their own definition of the situation which will inform their participation in that situation.

General psychological research has demonstrated how various factors can affect the individual's perception of a social situation and consequently his/her reactions to it: expectation or set (Bruner 1955); motivation (Postman, Bruner & McGuiness 1948); prior experience (Gregory 1966); physical context (Mintz 1956). Kelly (1955) in his Personal Construct Theory sees man as being in many ways like a scientist, continuously developing constructs which enable him to predict and hence interact with the world.
Research in the psychology of education indicates that there are individual differences in cognitive styles and, by derivation, preferred teaching styles e.g. holist/serialists (Pask 1976); focussers and scanners (Austin, Bruner & Seymour 1953); convergers and divergers (Guildford 1967) etc; Gage (1972) and Fox (1983) demonstrate various pervasive teaching styles which they propose may emanate from the teachers own theories about teaching and learning and the nature of knowledge.

This idea has some common ground with Pope and Gilbert's (1982) suggestion that teachers have a personal epistemology or perspective on the nature of knowledge and its development and Pope and Keen's (1981) argument that this perspective will influence teaching strategy and aims.

It is also echoed in:

"teachers have always been somewhat ambivalent about what it is they do for a living. An excellent case in point concerns their conceptions of the human mind. For example, there is the type of teacher who believes he is in the lighting business ...... when asked what he is trying to do with his students, his reply is something like this: "I want to illuminate their minds" ...... then there is the gardener ...... also the Personnel Manager ......"

POSTMAN & WEINGARTNER
1969 p. 86

All of these last sources support an argument, (quoting eminent work in the field), that language and thought, or conception, or construction of reality are intricately inter-related.
Some examples of these include the Whorf (1956) theory that language guides perception; Bernstein's (1961) description of the interactive effects of culture, class and language and Vygotsky's (1962) theme of language - thought conjunction. Therefore, it would be pertinent to study the presentation of explanations in a particular language form within the context of the teachers pedagogical style, as guided by their philosophies of teaching, learning and the nature of knowledge. It is possible that these are factors which may influence their rationale for using, or not using, figurative language in their teaching.

A metaphor used by Brown (1978), attributed to Aristotle, summarises neatly the need to address also the problem from the students perspectives:

'You get a better notion of the merits of the dinner from the dinner guests than you do from the cook' p. 86

Again, individual differences in the students in terms of preferred learning styles and theories about knowledge may affect how they interact with the teacher and their lessons:

'Students fundamental assumptions appear to exert a strong influence on the kinds of conceptual changes students are likely to find acceptable'

POSNER & HOAGLAND 1981 p.1
'Those who appear to need more than average social approval stress the importance of warmth and friendliness (White and Wash 1966) ...... most students appear to value enthusiasm and systematic presentation (Flood-Page 1974)'

BROWN 1978 p. 87

Smithers (1970) also notes that students who score high on scales of dogmatism express particularly strong preferences for clear cut, easy to note presentations.

These support the relevance of assessing these factors in conjunction with enquiry into the students' ability to understand the teachers' metaphors and analogies as well as gaining some indication of how they use them as part of the learning process.

In summary, then, the more refined research questions addressed are:-

1. Is figurative language used as an explanatory tool in science lessons?

2. How do teachers' philosophies of teaching and learning and the nature of knowledge relate to the use of made of figurative language:-
   (a) in terms of frequency of use;
   (b) in terms of mode of presentation;
   (c) in terms of purposes they expect it, or intend it to serve?
3. How do students philosophies of teaching and learning and the nature of knowledge relate to:-

(a) how they perceive and receive the figurative language used by the teacher;

(b) the use they make of it in their learning?

4. Is there congruency between the teachers intended use, mode of presentation and students perception, reception and use of figurative language and/or are there any unintended or unexpected repercussions in its use?

5. Are there any practical considerations and suggestions which can be offered to the teacher vis-a-vis the use of figurative language in the science classroom?
CHAPTER 3

METHODOLOGY
CHAPTER 3.

METHODOLOGY

3.1 THE PHILOSOPHICAL BASIS AND GENERAL ORIENTATION

The preceding review of the literature has indicated diverse perspectives on the use of figurative language in teaching and learning. The majority of these are generated from a theoretical assessment of the issue, tending in the main to be unsupported by empirical research into the practical situation in education. In order to redress this omission and, in particular, to address the questions posed in the previous chapter a review of the literature concerning research methods, their value and limitations, was undertaken.

Two factors from my own background guided this review. The first, and most influential, comes from my experience as a teacher with my students and with other teachers: our concern that research should reflect, and be applicable to the complex and often untidy world in which we practise. The second evolves from my experience as a scientist and from previous experience of psychological research in the quantitative mode. In some respects these factors generate conflicting concerns, pitting anxiety about authenticity, relevance and practical utility against that for control, rigour and consistency.
Relevant to this dichotomy, Gilbert and Pope (1982) describe two research paradigms with their entailed methodological commitments dependent on context and aims. (See Diagram I).

'The aim of the naturalistic approach is to describe a natural setting as fully as possible (holistically) so that a better understanding of such persons/events can be achieved. This is in contrast to the usual aim of experimental research which seeks to prescribe what future interrelations are likely to be between certain variables which have been the focus of the study.'

GILBERT & POPE (1982)

Following Denzin's (1978) advice 'the nature of the research problem and its relevance to a particular method should be assessed', I considered the following criteria in relation to my research:

a) the nature of the task, the main questions for resolution;

b) the perceived credibility and utility of the product;

c) the tools appropriate and available which could be used with skill.

To consider a) first, the nature of the questions posed implies that the study should take place in some part in the natural classroom environment i.e. with the minimum amount of constraint imposed by the investigator. The further ramification is that they address a complex situation in which only a few of the theoretically possible variables have been identified and defined.
Diagram 1 Paradigms in Educational Research
(Source: J. Gilbert and M. Poce (1982): Making use of research into teaching and learning, Module C, course study guide, DPHE, IED, University of Surrey)
Thus the 'experimental research' as described by Gilbert and Pope (1982) begins to appear inappropriate. Further, in their preface to the book 'Explorations in Classroom Observations', Stubbs and Delamont (1976) note the neglect of research in the classroom, giving as a major inhibiting factor the complexity of the situation. Their analogy, which compares some past educational research to the drunk who, having lost his keys in a dark part of the street, returns to the lamplight to seek them captures the essence of an approach which I wished to avoid in this initially exploratory investigation of figurative language use in the classroom-in-action. In addition, since one objective is to seek out 'differential information' and to allow for the interactive effect of variables such as teacher's intention and students' perception, further support comes from:

'It is the utter insensitivity of psychometric methods to all types of information which cannot be detected by their highly selective and artificial tests which makes them unscientific .... given a test with even only ten items suppose that two candidates both score seven, this score would be achieved by any of 120 different combinations of items. Since each item is necessarily a different piece of incomplete information which the candidate is required to complete, there is no guarantee whatever that the score 7 is obtained in the two cases by the same sequence of the same performance in handling the information. Yet the two are equated. Thus, the scoring of mental tests is a device for destroying information'

MEREDITH, 1972 pp 14-15

To consider next criterion (b), the naturalistic approach is again supported by Elton and Laurillard's (1979) argument that reductionist methods are inappropriate to teachers whose view of
the situation is holistic, and also by Entwistle's (1981) observation:

' - a total reliance on so called scientific methods may produce a restricted and unrealistic description of learning in schools or colleges'

ENTWISTLE, 1981, pp 243-4

Another characteristic of the naturalistic approach as described by Gilbert & Pope (1982) is an emphasis on a holistic approach. Again this would be in line with criterion (b) and is argued for by Rist (1977) thus:

' - it is precisely because reality cannot be broken down into component parts without the severe risk of distortion that a holistic analysis is necessary. Focussing on a narrow set of variables necessarily sets up a filtering screen between the researcher and the phenomena he is attempting to comprehend. Such barriers, from the vantage point of those employing a holistic analysis, inhibit and thwart the observer from a necessary closeness to the data, from an understanding of what is unique as well as what is generalisable from the data, and from perceiving the processes involved in contrast to simply the outcomes'.

RIST, 1977 p. 47.

This approach also has much in common with Edwards and Furlong's (1978) description of the methods of ethnographic researchers who, while making no attempt to control or ignore irrelevant features in interactions, intend their accounts to be derived from what actually happens rather than to be imposed from outside.
I was not unaware of its inherent problems and limitations, both ethical and methodological, as outlined in:

'The very sensitivity and flexibility which are the essence of illuminative research are also its Achilles' heel. The insights which emerge from qualitative research reports can appear too much the product of the researcher's personal perspective and of the idiosyncrasies of the specific situations examined. If the psychometric analyses impel the research towards over simple generalisations, the illuminative method can also mislead by swamping the researcher in particularities of doubtful general validity. But good qualitative research can through cross-checking of interpretations and through awareness of its limitations, provide evidence as strong in its own way as that derived from conventional approaches'.

ENTWISTLE AND HOUNSELL 1979, p. 361.

and in Rist's (1980) paper which notes the rush to qualitative research out of dissatisfaction with the quantitative paradigm rather than from more positive reasons:

'The result is that ethnographic research is now frequently done without an emphasis on values or on exploring the underlying cultural framework of the organisation in question. Description has come to be an end in itself'


Throughout the study I attempted to keep in mind the general advice and warnings contained in these quotations. Other more detailed problems and limitations will be reviewed, with descriptions of my own attempts to ameliorate or counteract them, in section 3.2, and in chapter 4, dealing with specific methods, fieldwork and analysis and in the discussion.
However, one particular common criticism is that an observer, no matter how well intentioned, can never understand fully the perspectives of the actors in a situation. This implies that account must be taken of the subject's own perspective and knowledge:

'Only by following the actors' perspectives can researchers avoid missing the subjective basis of the actions of those who they study'

TERHART 1982 p. 144

Not only is this important from the point of view of the researcher's understanding of the situation but it is also important from the point of view of credibility to the teacher who may find its results useful. In addition, Terhart also stresses, as does Magoon (1981) and Blumer (1966), that the situation should be interpreted in terms consonant with those used by participants in the situation.

As Pope (1980) pointed out, these ideas are congruent with the 'perspective of the personal' which is central to the work of George Kelly. Thus, with the general paradigm within which my research would take place delineated, the specific theory which guided my work came to be Personal Construct Theory. That this is peculiarly apposite for the many dimensions of this study can be seen from the following.
In 'The Language of Hypotheses', Kelly (1964) proposes that make-believe is an essential feature of science:

'science tends to make its progress by entertaining propositions which appear initially to be preposterous'.

KELLY 1964.

A comparison of this idea with the typification of scientific revolutions as involving paradigm shifts by Kuhn (1970) and the proposal by Petrie (1974) that 'interactive' metaphor creates an anomaly which leads to changes in cognitive structuring, makes an interesting collection of related ideas.

Further, Hesse (1966) notes that the individual's construction of events in the scientific context has a dependence on language;

"observation descriptions" are not written on the face of events to be transferred directly into language by are already "interpretations" of events, and the kind of interpretation depends on the framework of assumptions of the language community

HESSE 1966

Later, Sampson (1980) discusses the differences in individuals' perspectives on the world, suggesting that it is necessary that we sometimes look at things in a new way to improve on inherited wisdom. He relates this to actual language usage in which it is difficult to discern a distinction between the purely literal and the figurative in creative use.
Further, Ortony (1975) notes that, while students of metaphor may be constructivists or non-constructivists, the study of cognition involves perception, memory and language, each intimately related so that cognition is a result of mental construction or 'going beyond what is given'.

The link between figurative language, metaphor in particular, and personal construct theory is forged even more overtly by Watts (1978) when he describes metaphors and constructs as being species of the same genre, supporting this by quoting Mair (1976):

'Both Kelly and writers on metaphor suggests that all our approaches to reality are through the "screens" or "goggles" or "masks" which we construct'.

Thus, elements of this research: figurative language, science, and teaching and learning in the classroom are metaphorically bound by the psychological approach to their study.

Correspondingly, I then sought out the tools, (criteria C) germane to this approach. The requirements for these are described in Pope (1982):

'For Kelly, successful communication between people depended not so much on commonality of construct systems, but upon the extent to which people could "construe the construct system of the other" - i.e. have some empathy and understanding of someone else's construct whilst not necessarily holding the same constructs oneself'.

POPE 1982 p. 8
3.2 PARTICULAR METHODS

Certain characteristics of the 'Illuminative Evaluation' method (Parlett, 1981) were incorporated into this study. I set out to use:

(i) A custom-built design - in that, although adhering to some traditional principles, the detail of the design was negotiated and devised to fit the particular project;

(ii) A responsive approach - in that attempts were made to be sensitive to the requirements of the study, to its audience and to its participants;

(iii) A multi-method approach - in that account was taken of the different perspectives, i.e. those of the researcher, the teachers and the students;

(iv) A phenomenological approach - in that it was concerned with accepting the validity of personal experience, shared beliefs and ways of thinking embedded in the context;

(v) A humanistic viewpoint - in that it was concerned with and paid attention to human sensitivities;
(vi) The sequence heuristic - iterative - reflexive - in that as the study proceeded, new information was used to reflect on previous findings, and to stimulate new areas of investigation.

The final battery of techniques chosen (i.e. observation, interview, repertory grid and workshop), why each has chosen and the particular form that each took is discussed below.

(a) Observation

One of the first objectives of the research was to discover if figurative language is used in science classrooms. This therefore necessitated the observation of a number of science lessons by an observer who would recognise such language in its various forms. A lone observer rather than several was preferable for the following reasons. Firstly, an individual can maintain a definition of figurative language throughout the study so that its reported differential occurrence in different classes has a common basis. (My own categorisation of language in the transcripts as figurative was later informally checked by colleagues for consistency). Secondly, within a series of lessons with one class group, an individual can more readily cultivate the role of an inconspicuous, unobtrusive and accepted 'person-in-the-room'.
Thirdly, for the science lessons chosen - "A" level or equivalent chemistry lessons - there is a safety element to consider; an observer naive to the situation might well constitute, or be seen as constituting, a danger in practical sessions. Since I had once taught this subject, I was familiar with the general codes of practice and laboratory safety and had the additional advantage of being au fait with the technical language and jargon used.

In order to facilitate my acceptance in the required role by the class I planned to be present in a quiet corner of the classroom for several lessons before recording any observations, having previously carefully negotiated this role with the teacher and the class (see Section 4.2 - Fieldwork - negotiation of contract).

My attempts to maintain the persona of a non-partisan, objective, non-prescriptive observer owe much to the practical hints given by Dearden (1979). A quote from Sir Peter Medawar sets the scene:

'The first stage in a behavioural analysis is, of course, to observe and record what is going on. This will involve intense and prolonged observation until what an untrained observer might dismiss as a sequence of unrelated behavioural performances is seen to fall into well-defined and functionally connected sequences or behavioural structures'

MEDAWAR 1972
The format of the observations per se was that several lessons with particular classes were to be audio-recorded while I took notes about non-verbal behaviour (e.g. teacher writing on blackboard, teacher pulling a face, students shuffling about in seats), general atmosphere and physical properties of the classroom (e.g. background noise level, temperature, equipment, layout of room) and any particular incidents which might aid transcription of the tape (e.g. interruption by another teacher). To this end, I also collected a sample of handouts given to students, and copied diagrams which they were required to.

These observations were to serve not only to provide evidence of figurative language use, or non-use, but also to provide evidence of the teachers general pedagogical style to compare the observer's interpretation of this with that of the teacher and that of the students. Further, they would also serve to provide instances or examples of classroom incidents which could be later discussed in interviews. To paraphrase Hamilton and Delamont (1974), I hoped that this detailed study of a particular context would help to clarify relationships, pinpoint critical processes and identify common phenomena.

This relatively holistic and detailed method of observation data collection was chosen in preference to a traditional interaction analysis system (e.g. those of Flanders or Bales) because the
main restrictions of these systems, as detailed by Hamilton and Delamont (1974), represented the particular areas of importance to my study:

'Most interaction analysis systems ignore the context in which the data is collected ..... are usually concerned only with overt, observable behaviour. They take no account of the intentions which lie behind such behaviour ..... (They) are expressly concerned with "what can be categorised or measured" ..... (they) utilise pre-specified categories. If the systems are intended to assist explanation, then the explanations may be tautological'.

HAMILTON & DELAMONT, 1974 pp 322/23

Greenblat and Gagnon (1981 p. 97) describe a distinction used by anthropologists between explanations of behaviour deduced by observers (the ETIC) and explanations of the same behaviour given by the participants (the EMIC). They also question the implicit assumption

'... that the designer would possess some view of reality which was somehow either higher or better or more inclusive or more objective than the reality possessed by any single set of participants.'

In order to take account of this, the students were to be asked for their general interpretation of these classes and, in later interviews with teachers, my own analysis of the lessons would be discussed in relation to the teachers intentions and his interpretations of what had occurred. In addition, this would also help to elucidate why things happened while guarding against over-estimation of incidents which seem conspicuous to an observer but are seen as relatively mundane to the participants.
(b) Interview with Teachers

The rationale for choosing interviews as opposed to other techniques, such as questionnaires, is based on many considerations, not the least of which is described thus by Posner & Hoagland (1981 p. 12):

'the questionnaire helps to describe the tip of an iceberg; the shape of the submerged portion of the iceberg must be described with more probing techniques'.

It was proposed to include, during the course of study with a particular group, several interviews with the teacher about his/her role as a teacher, about what had occurred during class observations -

'Teachers own descriptions of their professional behaviour rest on explicit or implicit theories of teaching'

EDWARDS & FURLONG 1978 p.4.

and about his/her philosophy of science and particular methods used in the classroom to explain topics.
A final interview to discuss with the teacher my interpretations of the main ideas that he/she had expressed and what I had understood to have happened in the classroom would also be included.

For information about different interview formats and techniques I am indebted to Posner and Gertzog (1982), Laurillard (1979) and Pines, Novak et al (1978). The particular form chosen for this study was the semi-structured interview as described by Konald and Weil (1981) and is exemplified in their quote from Piaget (1929) that the effective interviewer:

'at every moment he must have some working hypothesis, some theory, true or false, which he is seeking to check'  

PIAGET 1929 p.9.

Thus, for each interview I had a series of areas on which I sought the teachers opinions, although the actual questions asked and their order was determined during the interview largely by the teacher's response to earlier questions. It was intended that my questions and comments should be generally non-prescriptive and, as far as possible, not coloured by my own attitudes and opinions but rather should be supportive and encouraging of the voicing of the others' ideas. In this I took as my guide Benjamin's (1981) work:

'The empathic interviewer tries as much as he possibly can to feel his way into the internal frame of reference of the interviewee and to see the world through the latter's eye as if that world were his own world'.  

BENJAMIN 1981 p. 49  
(original emphasis)
In order to facilitate this process and to avoid distracting myself or the interviewee, I decided to take notes only immediately before the interview about such things as its physical context and after the interview about the perceived state of tension of the interviewees.

The interview itself was to be audio-recorded so that a verbatim transcript could be produced. This also allowed for natural conversation flow with attention being given to the detail in what the interviewee was saying or not saying. This was the result of the great empathy I felt with Ekmans (1964) description of 'listening' in a verbal dialogue:

'Listening involves hearing the way things are being said, the tone used, the expressions and gestures employed. In addition, listening includes the effort to hear what is not being said, what is only hinted at, what is perhaps being held back, what lies beneath or beyond the surface. We hear with our ears, but listen with our eyes and mind and heart and skin and guts as well' 

EKMAN, 1964

As a caveat, Dean and Whyte (1978) point out:

'The informant's statement represents merely the perception of the information, filtered and modified by his cognitive and emotional reactions and reported through his personal verbal usages. Thus, we acknowledge that we are getting merely the informant's picture of the world as he sees it. And we are getting it only as he is willing to pass it on to us in this particular interview situation' (Author's emphasis)

DEAN & WHYTE 1978
It was hoped that this possibility of bias engendered by the single interview would be counteracted by: there being a series of interviews for cross-checking of recurrent themes or ambiguities; by having a record of observed classroom behaviour for comparison and as exemplar and, finally, by using the repertory grid technique for exploring some of the interview topics in more depth.

(c) Interviews with Students

The rationale for using interviews with students, rather than questionnaires for instance, follows that for the teacher interviews - the focus was to be on those areas pertinent to the individual student, within the general area of concern of the research, expressed in his/her own personal way. Thus, the interview format was again semi-structured and audio-taped, beginning with general questions and later following up 'leads' given by the interviewee.

The setting was to be as informal as possible and initially the students would be asked for simple background information and to chat about aspirations and hopes for the future in order to provide context for their ideas and to promote a more relaxed atmosphere. It was then hoped that they could be led into describing some of their understanding of areas within "A" level chemistry, with their own explanations of the reasons for this.
This would then lead to a focus on types of explanation - which were useful, or not, and why. Within the interview they would also be encouraged to enlarge on their own views about science in general, about the teaching and learning process and about their perspectives on particular incidents, or explanations, which occurred in observed classes.

The depth of study of each individual student was necessarily less than that for individual teachers since there could be time constraints both on the students and on myself as a researcher. Rather than having several interviews with a few individual students within a class, I felt that a broader perspective of student opinion on the issues at hand would be gained from interviewing as large a cross-section of a class as possible.

With questions such as these it was hoped that a greater understanding could be achieved of the utility or otherwise of figurative language, or conversely more literal presentations, to the receivers of explanations particularly in the sphere of science. The importance of tapping the students' perspectives in this context is emphasised in Watts, Gilbert & Pope (1982 p. 24):

'It can come as no surprise that comprehension between teacher and pupil would be at a minimum when both approach a discussion with widely differing frameworks. Understanding is an interactive process. Understanding is a process of constructing and modifying what is already known, or represented, and the new information to be known. It is a process that leaves neither part unchanged.'
and

'Successful science teaching requires an appreciation not only of the scientists view of the world, but also an appreciation of the language, beliefs and expectations which children bring whole and intact to science lessons'

WATTS, GILBERT & POPE 1982 p.3.

Similarly, Posner and Hoagland (1981) noted that some students' beliefs about science were considerably different from those of scientists, leading to learning difficulties.

However, it was also planned to cross-validate the data gained from students interviews with that gained later during workshops with small groups of the same students.

(d) **Repertory Grids with Teachers**

I proposed to use the repertory grid technique with teachers to explore in more depth two areas which had been discussed in the interviews, i.e. (i) how they saw their job and what it meant to them and (ii) how they viewed different kinds of explanation within the chemistry class context.
This technique is briefly introduced thus by Rivers (1981):

'The application derives from George Kelly's theory of personal constructs - Kelly saw each person as a unique individual who as he learns and goes about his day to day life builds up more and more elaborate conceptual frameworks using much the same methods as a scientist might. .... A particular construct system need not tend towards rationality as seen from an external set of standards, and every system will be different as it reflects the different experiences of each individual. This is not a particularly new idea in the history of philosophy but the attraction of Kelly is that he did more than present a philosophical position. In his technique of repertory grids he offered a method for the measurement of personal constructs'

RIVERS 1981

A more detailed description of the variety, applicability and differing techniques available within the domain of repertory grids is given by Pope & Keen (1981) and Fransella & Bannister (1977) from which I have learnt much which informed my practical use of the technique:

'Repertory grid technique is not a test but a method used to investigate constructs about people, inanimate objects and even abstract ideas'

POPE & KEEN 1981

'(It is) an attempt to stand in the other's shoes to see the world as they see it, to understand their situation, their concerns'

FRANSELLA & BANNISTER 1977

The particular form that I intended my use of this technique to take might be called 'a negotiated grid' to differentiate it from a 'supplied grid' in which the elements are supplied by the investigator and a 'free elicitation' grid in which the
participant has total control over the elements used. Although I agreed with Diamond (1977) that:

'elements should be representative of the universe of elements habitually used by the subjects themselves in describing the particular stimulus realm'

DIAMOND, 1977.

since this would then allow teachers to generate only those constructs they normally used, I also was concerned that a possibility might arise of the teachers not including some of their concerns as teachers which they had previously discussed in interviews or some of the explanatory techniques which they had used during class observations. A 'negotiated grid' would allow me, therefore, to suggest these as possibilities if the teacher did not produce them freely before considering the constructs, which would be freely devised by the teacher.

The negotiation of these grids was also to be recorded and transcribed verbatim because previous experience had led me to believe that much valuable insight can be gained from the little asides that people make while ordering the elements (e.g. 'when I was in training school I used to think this was more important than that but things are different when you hold the practical responsibility'). The transcripts would also be a useful permanent record of the participants elaboration on the meaning of constructs to them because often only a few words or short summary sentence is actually written on the grid.
The grids were to be analysed using Mildred Shaw's Focus programme (1980) to provide clusters of elements and constructs with varying levels of correlation. The possible meanings of these results would be discussed in a later interview with the teacher to provide additional data.

(e) **Workshops with Students**

These were planned to take place towards the end of the study when several examples of explanations or descriptions using figurative language—metaphor or analogy—had been collected. This would then be collated on to sheets to use with small groups of students in a workshop context. Each would be asked to assess these individually in writing and then to discuss them as a group.

The rationale behind this was that the written versions would provide data of first impressions while the transcript of the recorded discussion would provide evidence of more elaborated reasoning, particularly if individuals who felt strongly about a viewpoint found themselves in conflict with others:

'Situations creating conflict and controversy provide ripe moments to expose individuals most basic beliefs'


It was also expected that students might be more forthcoming and
A final objective of the workshop was to elicit from students other examples of metaphors and/or analogies which they had found useful in the past as explanatory tools and to ask them to describe in what way they found them useful.

3.3 THE CONCATENATION OF METHODS

During the course of data collection, and its analysis, each method was used both to reflect on and enhance the information derived from the other methods. This conjoining of methods, therefore, has much in common with the way in which Parlett (1974) describes illuminative evaluation as aiding the study of innovatory programmes:

'\text{the aims of illuminative evaluation are to study the innovatory programme; how it operates; how it is influenced by the various school situations in which it is applied; what those directly concerned regard as its advantages and disadvantages; and how students' intellectual tasks and academic experience are most affected.}'

\text{PARLETT 1974 p.15.}

By replacing the words 'the innovatory programme' with 'figurative language' a fair description of this present study would be achieved.
Denzin (1978) describes this process as 'between method triangulation' giving as its basic feature the combination of two or more different research techniques in the study of the same empirical units, adding that it:

'involves a complex process of playing each method off against each other so as to maximise the validity of the field efforts'

DENZIN 1978 p.304.

Further support for triangulation as a method of providing a fair representation of the different perspectives that participants within a given situation have of it comes from both Cicourel and Jennings and from Adelman:

'it (triangulation technique) provides details on how various interpretations of "what happened" are assembled from different physical, temporal and biographically provided perspectives of a situation'

CICOUREL, & JENNINGS, 1974

'Talk is not taken merely as a surface illustration but is questioned for meaning, pursued for discrepancies, placed in context over time, compared with other accounts, its intentionality elucidated through triangulation. These are not empty ruminations but an attempt to understand and so fairly represent the researched'.

ADELMAN 1981 p.5.

A brief summary of the information derived from each method and the reflexive links between methods is given on diagram II overleaf. This represents the co-ordination of information from any one of the
A STUDY OF METAPHOR IN CHEMISTRY CLASSROOMS

Key

METHODS USED

DERIVED INFORMATION

CLASSROOM OBSERVATIONS

REP. GRIDS WITH TEACHERS

PHILOSOPHIES OF TEACHING, SCIENCE AND COMMUNICATION

GENERAL ORIENTATION AND STYLE

USE OF METAPHOR

WORKSHOP WITH STUDENTS

APPRECIATION OF EXPLANATIONS

VIEWS ON SUBJECT AND SCIENCE IN GENERAL

GENERAL BACKGROUND

INTERVIEWS WITH TEACHER

RELATIONSHIP WITH TEACHER

INTERVIEWS WITH STUDENTS

RELATIONSHIP WITH STUDENTS
classes studied, the teacher and his/her students. Each class, therefore, represents a case study, two of which will be described in detail later (Chaps. 5 and 6). Cross-case study data is also presented (Chap. 8) when a summary of students and teachers perspectives is given.

MacDonald and Walker (1977) say of the case study method that it 'gives insight into specific instances, events, or situations', portraying the participant's experiences as they 'relate to their own circumstances, concerns and preferences'. Zubir's (1983) thesis provides additional support and she lists the main values of a case study approach. These may be summarised as, that it: is strong in reality; allows for generalisation either about an instance or from an instance to a class; recognises the complexity of different perspectives; provides a rich data source and allows the readers to judge implications for themselves.

Given that the format for the research is now described, I can do no better than to quote Bruner's (1980) words:

"For as Barlett (1.p.1) puts it,

"Whenever anybody interprets evidence from any source and his interpretation contains characteristics that cannot be referred wholly to direct sensory observation or perception, this person thinks. The bother is that nobody has ever been able to find any case of the human use of evidence which
does not include characters that run beyond what is directly observed by the senses. So, according to this, people think whenever they do anything at all with evidence. If we adopt that view we very soon find ourselves looking out upon a boundless and turbulent ocean of problems!"

Bother though it be, there is little else than to plunge right in'.

CHAPTER 4

METHOD AND PROCEDURE
The initial concern was to identify the target population of my research. The general area of interest was the use of figurative language in science classrooms; the particular science classrooms - A level chemistry classrooms - was defined by my own area of expertise and interest. The first part of the fieldwork involved the choosing of a sample of these classes which would most adequately reflect the aims of the inquiry - since the inquiry demanded frequent and prolonged observation of classes involved in their normal activity and also required time and effort on the part of the participants in the classes for the interviews, repertory grids and workshops, the sample chosen had to be relatively easily accessible and to be both willing and able to take part in such a study. The sample choice was further restricted in terms of size by the ability of an individual researcher, within time and fund limits, to do full justice to the data derived in terms of in-depth, reflexive analysis.

Therefore, a decision was made to contact all the accessible schools with A-level or equivalent chemistry courses with a view to discussing with the relevant people the aims and plans for the research, so to gain their cooperation. From those willing and able to participate would be chosen a representative range of
classes to be studied at various depths:

8 classes to be generally observed, with short teacher and student interviews;
5 of these 8 to be studied in greater depth with several sets of more in-depth interviews and grids;
2 out of these 5 to be taken as case studies, using the whole range of reflexive, triangulation techniques described earlier.

Consequently, the first part of the fieldwork, of three months duration, was the negotiation process with schools (to be described in the next section) followed by a pilot study within one of these during which the research instruments were tested and refined. Briefly, this involved –

for observations, discovering ways of: minimising the obtrusiveness of the observer; maximising the recording of the interaction both by notetaking etc. and by distribution of audio-recording apparatus;

for interviews, grids and workshops, discovering the most facilitative physical environment, and mode and form of question and response, again maximising the recording of the interaction.

The pilot study also served to increase the perceptiveness of the researcher, myself, and to alert me a) to possible environmental constraints on the research (to be discussed in section 4.3) and b) to the variety of interactions in other teachers' classrooms.
The plan for the main part of the fieldwork was to follow the sequence shown below up to the required stage for each class.

<table>
<thead>
<tr>
<th>Approx. week no.</th>
<th>Fieldwork Component</th>
</tr>
</thead>
<tbody>
<tr>
<td>i) + ii)</td>
<td>Class observation without audio recording (preferably at least 4 lessons).</td>
</tr>
<tr>
<td>iii)</td>
<td>Class observations with audio recording + Teacher interview (Role as Teacher)</td>
</tr>
<tr>
<td>iv)</td>
<td>Class observations with audio recording + Teacher interview (Teaching methods used and why)</td>
</tr>
<tr>
<td>v)</td>
<td>Student interviews</td>
</tr>
<tr>
<td>vi)</td>
<td>Teachers Rep. Grid I (Role as Teacher)</td>
</tr>
<tr>
<td>vii)</td>
<td>Teachers Rep. Grid II (Methods used in Teaching)</td>
</tr>
<tr>
<td>viii)</td>
<td>Final Interview with Teacher (Discussion of: Analysis + summary of derived data)</td>
</tr>
<tr>
<td>After Term Exam</td>
<td>Workshop with Students</td>
</tr>
</tbody>
</table>

The reasons for this particular sequence were:

a) Four lessons, i.e. approximately two weeks, of the researchers presence in the class before audio-recording would allow the teacher and students to become familiar with the situation so that 'observer effects' on normal practice...
would subside; it would also allow me to become familiar with the general ethos of the classroom and school.

b) Classroom observation with recording could then begin more effectively when the teacher started to explain a new topic area.

c) The preliminary observation time period also would allow the teacher to develop a certain trust in myself as the researcher and to develop a mode of communication with me through frequent interaction which would allow the interviews to be more informal and less restrained.

d) The student interviews were to take place after the lesson recording so that they would be familiar with the technical language of the new topic area and would have heard several explanations during its course. This would also allow them to express their opinions without feeling obliged to perform in a certain way in the classroom afterwards.

e) The rep. grids with teacher were deliberately delayed until after the observations and interviews and their preliminary analysis so that these latter could be used to help negotiate the grids. Another important reason
for this delay was that there was a possibility that the in-depth thinking which these grids encourage might influence the teachers subsequent practice in the classroom.

f) In addition to allowing time for a sufficient number of metaphors, analogies etc. to be collected, the student workshop was not timetabled until after the term exams for two reasons. The first was that it would allow the students to reflect on how and why they used/did not use various examples in the practical situation. The second reason was that, post-exams, they would feel less constrained to perform in their perception of the 'academically-required' manner during the workshop i.e. they would be more likely to express the way they do think, remember etc. rather than the way they think they ought to.

Ideally the sequence should be followed through for one class at a time to allow time for analysis and 'immersion in the data' for that class. How this worked out in the less-than-ideal practical situation is discussed in section 4.3.
4.2. NEGOTIATION OF CONTRACTS

Initially a copy of an introductory letter (Appendix I) was sent to the Head of each of five schools and interviews arranged. During each interview a brief resume of the main areas of concern and general research strategy was given, with stress being placed on the maintenance of confidentiality about individual views (teachers and students) and the anonymity of the school. When an understanding about these matters was reached, arrangements were made concerning permission from the local authority for the exercise, meetings with the teachers to be involved and, if necessary, their Heads of Departments, and the availability and use of resources and facilities within the school.

The subsequent interviews with prospective participant teachers consisted of more detailed discussion of the problem area and its concerns, including my own philosophy and proposed methods of research. Until the last interview, my particular interest in figurative language was not disclosed to guard against this changing the teachers normal delivery. Instead, I spoke of my interest in different forms of explanation. The teachers own opinions and suggestions were sought about the practicalities of the research so that a mutually agreeable programme could be devised. Again this included agreement about anonymity and confidentiality and possible strategies were discussed whereby the students and teachers could be assured of my impartiality.
while the normal running of classes could proceed with the minimum of disturbance. An illustration of a strategy which was devised to incorporate consideration of both of these points is that I would arrive shortly before the teacher and students entered the classroom to set up equipment and take my place, and dismantle equipment and take my leave shortly after the whole class had left. This meant that the possibility of my being viewed as another teacher or employee of the school, coming and going with the teacher, was lessened. Teachers were willing to cooperate with this objective, agreeing also not to be seen chatting with me before, during or after a class. This did not preclude discussion at a more diplomatic time and place, such as coffee breaks in the staffroom, which were often the source of much useful background information.

Finally, teachers agreed to allow me to introduce myself and my purpose to the students so that I could negotiate my own contract with them. I felt that it was important that the students should be aware of my version of the objectives and methods of the study so that a better rapport could be gained, although, of course, it was impossible to guard against speculation and discussion during the times that I was not present.

My introduction to the students took the form of my giving my name and describing myself as a research student from a university, interested in the kind of explanations given in
chemistry lessons. I explained that not only was I interested in which forms of explanation teachers thought useful but that I was particularly interested in what students, as the 'customers' in the exercise, thought about them, how they used them and so on. I then said I would be grateful for their help in allowing me to sit in with them during their lessons and, at a later date, that I would find it especially useful if some of them could oblige by talking to me privately about some of the things they had heard and read about chemistry. I concluded by making it clear that I was in no manner concerned with assessing their personal learning, chemical ability or their teacher's teaching ability but was interested in which kinds of explanations suited, and best helped, people with a wide variety of interests and backgrounds.

Having gained initial agreement, and the beginnings of rapport, with the participants of the project, plans were then made about the practical arrangements for the study: timing, what facilities would be available etc. In all cases, teachers provided me with their class time tables and termly calendars of events, along with brief summaries of their proposed schemes of work, all of which proved extremely useful when the practical fieldwork was undertaken.
4.3. FIELDWORK IN OPERATION

The actual number of schools which fulfilled the initial criteria of being accessible and running the required course was five. All of these were sent the letter described in the preceding section. From this sample, two felt that they could not take part in the research. No reason was given by one, while the other had recently been involved in unpleasant publicity after an incident at the school. Although other less accessible schools were available, I decided that the remaining ones in the sample would give a reasonable cross-section of local authority schooling at this level since they included a college of technology and a sixth form college, both taking students from the same large catchment area including several secondary schools, and also a comprehensive school which had its own sixth form. Each one described its own aims and objectives and general atmosphere somewhat differently in their respective prospectuses and a difference in general ethos was readily observable to the visitor in terms of formality of dress and general behaviour on the part of both staff and students, including that towards each other. A fuller description of the ethos of each school from the perspective of the researcher will be given in the data section which also includes comments by teachers and students on that topic (Chaps. 5, 6 & 7).

In all cases it was possible to follow the order of the proposed schedule (Fig 1) although some difficulties arose in some cases
over the intervals between items and in completing the study of each teacher/class component sequentially. Although a whole school year was in principle available for the fieldwork component, in practice the most suitable times, with regard to the research and with regard to minimum disruption of the school calendar, were restricted by many factors, viz: a few weeks had to be allowed at the beginning of the academic year to allow for induction to courses and to allow students and teachers to get to know one another and to establish a working pattern; allowances had to be made during terms for school trips abroad, fieldwork trips, sports days etc; allowances also had to be made towards the end of terms for either school festivities (concerts etc) in which students were involved or for exams which had to be set, taken, marked and discussed. Other less regular occurrences also had to be taken account of such as teacher illness, a teachers work-to-rule (which in one case led to a student 'picket line'), unexpected promotion or job change and even an unexpected pregnancy.

The main result of these restrictions was that there was an overlap, in most cases, of schools or teachers/classes being studied at any one time. This in turn had implications for the analysis which occurred between sessions with a class. Instead of transcribing each lesson and interview verbatim and analysing it in detail before the next session, which would mean a lengthy time gap and possible memory loss for the participants, the
the best compromise was found to be to listen several times to a tape making a rough transcript of the main points and themes. The only exception to this was that before the final interview with the teacher, all the data from that class (except for the workshop data) was transcribed verbatim and analysed. This often necessitated a lengthy time interval (in the region of a month) between the last rep. grid and the final interview but the teachers concerned said that they had little difficulty in remembering what they had said, had meant and why in earlier sessions since they had the scripts before them. In some cases, they were also willing to discuss changes they had made in methods or opinions since those sessions, raising some interesting points about the advantages and disadvantages of the methodology used in the research which will be discussed in section 9.1.2.

Another consequence of the 'unexpected occurrences' was that to some extent those who contributed to the full range of methods in the study, i.e. completed the sequence, were self-selecting or, rather, remained in the study while others by force of circumstances had to curtail their involvement. Fortunately, those remaining continued to be willing and interested so that I did have a choice available about on whom to conduct the full case studies.

As well as affecting the time sequence of the research study, practical considerations also influenced the location of
different parts of the study. Fortunately, the classrooms were all large science labs so that it was not difficult to find a quiet corner from which to observe the lesson. Since the tape recorder was quite compact and had a very small microphone attached by a long, fine cord it was also possible to position it unobtrusively so that the controls were within my easy reach while the microphone could be so positioned that it picked up all public verbal, discernable discourse in the classroom. There were occasional problems of noise from outside the classroom but these were overcome by relocating the microphone etc.

The locations for the interviews and grids were sometimes less than the ideal of a small quiet, comfortable room, free from interruptions. In some cases such a place was found but in others it was necessary to conduct the interviews in laboratory preparation rooms – the worst case being one which most nearly resembled a cupboard. However, within these confines every attempt was made to make the participants feel at ease: usually the interviewer and interviewee sat at about 70° to each other, with, for example, the tape microphone unobtrusively attached to a pile of books between them. Prior to the interview I had explained to them why I would like to tape it i.e. to provide an accurate record and so that I would pay more attention to what they actually said than I could when taking notes. Each participant agreed to be recorded. The recorder was switched off and the interview suspended if anyone else entered the room,
both being restarted when that person left. Incidentally, I did offer each participant the opportunity to listen to their own tapes but this offer was never taken up although several teachers thought they might like to listen to their lesson tape 'at some time'. I felt that this offer should be made so that the participants could feel more in control of the data which they provided, this suggestion being consistent with the idea that they were 'participants in' rather than 'subjects of' the research.

Since the workshops took place after the term exams, when academic activities were somewhat curtailed, it was not difficult to negotiate the use of small common rooms which were conducive to small group, informal discussion. (This was further aided by the provision of coffee and buns). Responding to a written invitation describing the activity, the participants were all volunteers from the groups of students who had already taken part in the research.

The actual time of interviews with teachers was arranged to coincide with free time or preparation time on their timetables. For students there was some variation between schools, some being private study periods while others preferred this to take place outside school hours, either at lunch time or after the afternoon session. In the latter case, so that the sample of students was not restricted to those who lived in the immediate vicinity of the school, it was sometimes necessary to provide transport home for interviewees.
On the question of sampling teacher participants within any school, it should be noted that all were volunteers. This was essential to obtain the necessary rapport and response in interviews and to provide as natural, unconstrained examples of lessons as possible. This in effect meant that only those chemistry teachers within a school who felt that the study would not disrupt their lessons or style took part. This has some complications for the generality of the findings which will be discussed in 9.1.1. However, this meant that 2 teachers from two schools and one from one school took part, ie the whole chemistry department of 1 school, and half the department for the other two.

Similarly, the student participants were also volunteers for interviews. After the lesson recordings, I asked for student volunteers who would not mind talking about their ideas and understandings. There were always several, all of whom were interviewed. I then asked the teacher if they represented a fair cross-section of the class. In the few cases where it was not, I would again ask for more volunteers which were forthcoming, presumably since their fellows had assured them that it was not a traumatic experience. This practice was followed until I had interviewed either an agreed cross section or the whole class if it was small. The actual numbers and proportions taking part are given in the case studies (chaps 5 & 6) and summaries of case studies (chap 7).
Each student was given an appointment card recording my name and the time and date of the interview with the location of the meeting place. This seems to have been a useful practice since on no occasion did a student fail to meet an appointment - each arriving at the appointed time with card in hand.

In order that full concentration could be given in each interview, it was found in the pilot study that the maximum number of interviews which could be conducted in any one day was six, with the optimum being four. This did mean that students had the opportunity of discussing the interviews with their fellows but I could perceive little disadvantage in this because no subterfuge was involved, the general area of questions had already been divulged to the class as a whole and the actual course of each interview was determined by individual factors such as which areas each student found most interesting, easy, difficult etc. The aforementioned advantage of stimulating more volunteers was a result of having the interviews over several days, although there was no perceivable effect on the distribution of shy and articulate students from the first to the last day of interview for any one class, only a very small number overall requiring much stimulation before expressing their views. However, there was a between school difference which will be discussed in 7.3.5.
4.4. METHODS OF ANALYSIS

General method:-

The audio-tapes were listened to several times to familiarise myself with accent, intonation, general mode of speech and expression. These tapes were transcribed verbatim with the aid of any relevant notes made prior to, during or following recording. (see Appendix (IIb) for sample).

Each transcript was read through several times, highlighting in various colours areas of special interest. By employing a method involving many transcript readings accompanied by listening to the tapes - 'immersion in the data' - categories were derived from the data rather than imposed on it, preferably using the participants own words. For instance, one teacher may express a 'preference for' ordered, logical progression in his teaching while another may suggest that he 'prefers a given framework to work within'. Each may then go on to amplify and exemplify these ideas in that or later interviews and rep. grids. While working within any one individual's data it aids understanding of his/her perspective, and allows for continuity, if his/her phraseology is also used. When comparing teachers, such a method also prevents the kind of misapprehension occurring which would result from having preconceived categories such as 'prefers structured approach' since either, neither or both may not mean precisely this.
Once a set of categories was devised for a particular transcript, it was then read through again while listening to the tape (to preserve context) in order to collect all the examples of each category and to choose suitable representative quotations.

Particular Methods

1) CLASSROOM OBSERVATIONS:

Once the general flow of the lesson had been thoroughly assimilated, the lesson was broken down into general sections determined by both what the teacher said he was doing and by the words used eg. 'introduction to the general area of study for the lesson', 'summary of previously-covered relevant knowledge', 'explanation of new idea' etc. These were then broken down into sub-components by description of what the participants did eg. 'student asks question', 'teacher draws diagram', 'teacher tells anecdote' etc. These are referred to as lesson units, their particular names being derived solely from each individual transcript. I felt that these were more useful units than purely time units into which to divide lessons for the purposes of this study since it is more useful to see what elicits or composes an explanation than to know how long in minutes it took. Thus, these units were plotted in sequential order - see appendices IIC and IIIc for case studies - so that any patterns (such as recurring unit sequences) could be discussed, and so that an overview of the lesson would be achieved from which the frequency
of occurrence of figurative language, jokes and digressions, student questions, reference to everyday experience etc could be readily observed.

In addition to highlighting features particularly connected to explanations this method of portraying the lesson also facilitated interpretation and description of the teachers pedagogical style and the level of student/teacher rapport.

INTERVIEWS (TEACHERS AND STUDENTS)

Each tape was listened to several times while reading the transcript so that a general view of attitudes and opinions most salient to the participant could be discerned. The transcripts were then highlighted in different colours according to these general categories, the process being repeated until all of the main remarks had been covered and sufficient categories devised to accommodate the various perspectives that the participant revealed. The quotations for each category were then collated and transposed on to separate sheets, with frequent referral back to context to clarify meaning, so that a summary of main opinions and attitudes, with supporting quotations, could be compiled. Any apparent ambiguities or contradictions were noted for later checking with the individuals concerned.
REPERTORY GRIDS: (Hereafter described as 'grids').

These were initially analysed by computer using Mildred Shaw's Focus Program (1980) the element and construct trees being drawn by hand. An example can be found in Case Study I. Fig 2 The clusters and relationships between clusters were noted, with back reference to the extended definitions of elements and constructs given by the teacher in the taped and transcribed grid session. In addition, prominent patterns and notable rankings within the array were also highlighted e.g. markedly skewed distribution of elements between the two poles of a construct.

The transcripts of the sessions were also analysed as for the interviews, this data being used in the interpretation of the grids. The full interpretation of grids and ancillary data were later discussed with the teacher in the final interview.

WORKSHOPS:

The written notes, on each sample of figurative language, made by the students were compiled into tables to show such features as 'acceptability', 'usefulness', 'appealingfulness'. The numbers of students participating were too small to make effective use of statistical analysis but general trends could be noted. Samples of these written notes can be found in Appendices IIId and IIIId. The transcripts of the workshops were read several times in
conjunction with listening to the tapes so that recurrent themes and ideas emerged eg. 'helps me to remember', 'lets me visualise it'. Categories were derived from this and the transcripts analysed in terms of these.

GENERAL POINTS:

Each of these method components were initially analysed independently ie. without reference to each other. In addition, 2 small workshops, one for each case study, were run with university research colleagues in which they were provided with unmarked transcripts, a sample from each component. They were asked to analyse these in their own way to discern major themes, attitudes etc. or predominant teaching styles. These were then discussed in the group. This was not intended as a measure of inter-judge reliability, since my colleagues did not have all the background knowledge that I had, but rather to provide general support for categories derived, to check on subjective bias and to eliminate as much as possible any major omissions from the data analysis. In general, there was agreement on general categories although in one or two cases possible alternative interpretations were noted and possible ambiguities highlighted. Since these sessions took place before the final teacher interviews, it was possible to check these ambiguities out with him/her.

Once all of the individual components had been analysed then data from each were crossed checked both within-individual and within-
class. As an example, the main ideas expressed by a teacher about teaching and learning in each interview and in the grid session were compared with what had occurred in the lesson, while his/her interpretation of what generally occurs in the classroom was compared with the students' various views on that subject.

The results of analysis for 2 particular classes are described in Case Study 1 and Case Study 2 (Chaps 5 & 6). Results from the other classes studied are presented as summarised case studies in chapter 7. All of the research data is coordinated in chapter 8 in the form of tabulations. Patterns identified from these tabulations and the main data are used in that chapter to answer the research questions.
CHAPTER 5

CASE STUDY 1
CHAPTER 5. CASE STUDY 1

5.1.1. GENERAL BACKGROUND

The school in which this case study was conducted is a large technical college which offers a very wide range of subjects including A level chemistry. The prospectus refers to learners as "students" (as opposed to pupils) and the general tone of address is as to adults. There are no general formal dress regulations and, in the department concerned, staff introduce themselves to students giving their full names, indicating a preference for being called by their first names.

From staff room discussion, from general observation of the department at work and from general student comment, an ethos of general informality in relationships emerged, although some staff seemed more relaxed with this than others. The impression was gained of power being gently, unobtrusively wielded unless individual students were perceived to be taking undue advantage of this to their own or others detriment.

The common arrangement of timetables in the department is for 3-hour lessons, which may be either lecture or practical sessions, usually two per subject per week plus a 2-hour tutorial session. The usual arrangement is that students take three A levels over 2 years although in each class there were some students who were studying A levels in one year and consequently
attended both first and second year classes (Intensive students). This applied to some students in this particular second year class studied.

This class contained students who ranged in age from just 16 years to 23 years old, some coming directly from secondary school, some from sixth form colleges, and some returning to full-time study after a period at work. The majority were in the 17-19 years old range. All the students had the basic minimum of five O levels, a few having also one or two other A levels and three already having A level chemistry but at a grade lower that that which they required to continue their education. Therefore, the level of familiarity with, and expertise in, chemistry was varied throughout the class.

5.1.2. TEMPORAL SEQUENCE OF STUDY

The order of the fieldwork components followed that as described in Section 4.1, with a slight alteration being made in the timing of the teacher interviews. Although I had originally planned to have two separate interviews with the teacher (the first focussing on general teaching role and ideas about science and the second being in more depth and concerned with ideas about communication and explanation) in practice one long interview took place. The teacher had indicated that he had plenty of time to spare that day and, further, it became apparent as the interview proceeded that he was becoming increasingly relaxed and ready to
to discuss matters in more depth. I therefore decided to incorporate the questions from the proposed second interview into the first one.

The fieldwork began with lesson observation in the fourth week of the first term, the teacher having indicated that he now felt that he had got to know his students and was about to start a new topic. The audio-recording equipment was set up for all classes but not activated until the fourth lesson onwards, i.e. until the teacher and the students gave indication that my presence and the equipment had become less obvious. The kinds of indication were: no overt or furtive glances in my direction when comments, jokes, etc. were made; student and teacher chat became more informal and relaxed; no verbal references were made to the observation, such as "I've got that on tape now".

The main lesson used as examplar and for analysis of teaching style was the fifth lesson of the series. This one was chosen firstly because it seemed to be of similar format to the preceding and subsequent lessons and secondly because during the teacher interview on the following day a comment was made which indicated that my presence then had been particularly unobtrusive. While discussing a particular analogy used in that lesson involving 'malignant dwarfs', I made a joking comment about being short of stature myself. The teachers reply was:

"Ha, ha, well, no, really, I completely forgot about you yesterday ---- it didn't pass my mind that you were there - you'll have to stand up a bit higher - ha, ha".
The final teacher interview took place in the last week of the first term, while the student workshop took place after their main exam at the beginning of the third term.

5.1.3. **LOCATIONS OF FIELDWORK COMPONENTS.**

The classroom observations all took place in the same large laboratory which had a teachers bench on a slightly raised platform at the front, behind which were the blackboard and O.H.P. screen. The students were seated along three large workbenches facing the front. The laboratory was fairly well insulated from external noise, except for occasional overhead aircraft.

The room used for the teacher interviews and grid was a small preparation room equipped with stools and a workbench. Although perhaps not having the comfort of an ideal interview room, it was one with which the teacher was familiar and in which there was a low probability of interruptions from outside.

The room used for the student interviews was a small tutorial room with a low table and comfortable chairs. Again this room was one in which interruptions from outside were likely to be infrequent and in addition was in a separate part of the building to the science department, so aiding the impression I hoped to emphasise, that is, that the interview was not in any way connected with assessment etc. within the department.
The student workshop took place uninterrupted in an informal common room with coffee facilities, a large work table and comfortable stools.

5.1.4. PARTICIPANTS

The teacher, Mr A, had spent the 18 years (approx) since obtaining his degree in teaching chemistry and related subjects in this school. Some eight years prior to this study he had studied part-time for, and gained, a teacher certificate. His dress was generally smart but informal, occasionally topped by a white lab. coat when demonstrating chemical reactions.

The students in the class as a whole numbered 16, those taking part in the interviews being eight in all while four formed the workshop. There were six young ladies in the class and the proportion of males to females in the class was maintained for the interviews. The interviewees also spanned the range of age, previous chemical education experience and perceived (by the teacher's assessment) ability in the class.

5.1.5. FIELDWORK EXPERIENCES WHICH AFFECT THE ANALYSIS OF DATA

During the course of a series of interviews, classroom and informal interactions with teachers it became apparent that with time they became increasingly relaxed and, in some respects, more articulate. Indicators of this were that they were more inclined
to expand on ideas, give personal examples or anecdotes or perhaps use less technical terms in responses, instead using more common or expressive wording. This is to be expected as a relationship develops and was aptly illustrated by Mr. A himself while he was discussing a point about teaching which disturbed him. His point was that some students could discuss ideas adequately in class, although they had difficulty in providing written versions, but would find an oral exam too awe-inspiring:

"- there are too many pitfalls in an oral ... I think .... oh you must know ... WE'RE far more relaxed now, an hour into this, than we were in the first few minutes, and you think of a kid - one off - going in to see someone and chatting - for an exam .... its an impossible situation - personalities etc etc.".

The implications that this has for analysis of data is that particular quotations must be viewed within the context not only of a particular interview but also within the total context of the research interaction. A synopsis of the kind of remarks which were made during interviews supports this:

"Earlier I said that my main aim was to maintain high pass rates, well, O.K., I do see that as a commitment of the job, but in a way I undersold myself - it really covers a multitude of underlying needs, motives, - call 'em what you like".

A further point, although the actual repertory grids produced by Mr. A were comparatively small, thus revealing only a few points of interest in themselves, the taped and transcribed negotiation and discussion around the grid demonstrates their value in
serving as a catalyst for in-depth discussion of many points only briefly touched on in the earlier interview. For instance, in the interview, while discussing a personal anecdote used as an analogy, Mr. A mentioned that this was a technique that he saw as part of a teaching style which naturally suited him. While deciding how to rate the element 'anecdotes' for various constructs, he explained at length not only how and why he used them but also the doubts that he sometimes had about his general teaching style, and the measures he sometimes took to check on or alleviate this. This demonstrates the importance of co-ordinating the data derived from the various component sources in arriving at anything more than a superficial view of a person's attitudes and opinions.

Finally, it should be noted that the research topic defines the original questions asked and also the remarks and practices followed up in interviews. This could result in an interpretation which suggests that the researcher's concerns are of particular importance to the participant but it should be noted here that attempts were made in the final interview to check that no undue emphasis was placed on a particular attitude or opinion simply because it was frequently expressed in response to the many questions asked on that topic area. As an illustration of this, pertinent to this case study, let me give one example.
Since one focus of the research is on the explanatory power of figurative language, many of the questions, or followed-up remarks, in interviews were concerned with understanding. This inevitably increases the attention paid either to areas that are generally difficult to understand or to students who have particular difficulties in understanding. Thus, many remarks of the teacher are addressed to these areas and methods used to overcome the problems. This could lead, when analysing transcripts, to a perhaps unjustified assumption that these were a major concern or interest of the teacher. This possibility was put to Mr. A in the final interview, that is, that an impression could be gained from what he had said earlier that he had a preference for teaching the average or struggling student. He replied by elaborating a more detailed description of his attitudes towards teaching students of different abilities:

"I admire people that find it quite easy but if they do tend to dig out more difficult problems - its always a PLEASURE to chat to them about these things because I can cope with it and its interesting -- its nice for people to ask these (difficult) questions because it makes the other kids - who are just sitting back accepting it - realise that there are questions to be asked about it" (teachers own verbal emphasis)

and

"people that really struggle, now --- providing their attitude is right ( --- ) providing they are prepared to ask questions and come to you ( --- ) then its a PLEASURE to go through it with them because you feel you're doing something useful and constructive."

Thus, care has to be exercised in analysis particularly in the realm of misassigning attitudes and opinions to people as a
result of emphasis on the answers to 'asked' questions and neglect of possible answers to 'unasked' questions. A corollary of this is that, during a protracted research relationship with individuals they too make assumptions about one's research interests, based on the types of questions they are asked etc., and may then, wittingly or unwittingly, place relative stress on different aspects of their interests and opinions etc.

5.2.1. DATA FROM CLASSROOM OBSERVATIONS

The lesson, termed 'lecture' in the college, was of 3 hours duration with a 20 minute coffee break about midway. A synopsis of the lesson in terms of teaching units is shown in Appendix IIC.

A first general impression of the lecture was that there was a large degree of interaction between the students and teacher, the latter more often standing, or walking about, within the main body of the class than remaining behind his bench. The main time he was in that position was when he was drawing or writing on the blackboard or showing a transparency on the OHP. Occasionally he would also consult notes on his bench or collect handouts which he distributed to the students. These were of the 'partially completed' type on which the students could fill in the equations, definitions, diagrams etc. The verbal response of the students seemed relatively high in that there seemed to be a willingness to respond to teacher-instigated questions and to
ask questions of their own. There was a general air of informality - the teacher was addressed by his first name and students did not seem restrained from addressing quiet remarks to each other. However there seemed also to have evolved a 'working atmosphere' in that there was no hint of indiscipline or distracting behaviour from students and in general they seemed to attend to the topic under discussion. There seemed also to be frequent changes in pace with many different activities involved in by students and teacher. The analysis of teaching units with their constituent techniques or episodes produced the following information:

(a) Most of the lesson was conducted in informal language although formal language, i.e. with grammatical sentence structure and containing the technical terms of science, was interspersed throughout the lesson in the form of summaries for notes, or repetition of an informally discussed theory or principle in the form that students would meet it in textbooks.

(b) One general pattern that emerged was a repeating sequence of the teacher pointing out or posing a problem within a topic (as opposed to asking questions of the students), then general classroom discussion and expansion of the ideas involved, followed by a teacher's summary or generalisation derived from the discussion.
(c) Throughout the lesson there was frequent verbal interaction between teacher and students, dialogue as opposed to monologue: 18 student-to-teacher questions, 14 teacher-to-student questions (sometimes to individuals, sometimes to the body of the class) and 17 question and answer sessions involving individuals or the class as a whole. The latter sessions were classified separately as they appeared to be a particular strategy used by the teacher and took a general form:

S: "Why is that then?"
T: "What do you think, any ideas?"
S: "Well, I was thinking it might be . . .".
T: "Yes, that's part way but what about . . .?'"
S: "Could it also be . . .?"
T: "We're getting there - let's look at it in . . .".

These session became more frequent in the second half of the lesson.

(d) Throughout the lesson explanations involved different modes of presentation. The following modes were interpersed throughout the lesson: 24 metaphors, analogies, 'imaginary' experiments and anecdotes relating to theory; 30 references to previously learnt or 'well-known' knowledge; 31 visual presentations (i.e. demonstrations, diagrams on blackboard or OHP); 7 links to other areas of the subject or other subjects; 9 references to practical or everyday uses;
9 hints for memory aids or for exam-passing techniques.

Among these were frequent references to the teachers and/or the students' own experience. It is also noted that 8 of the metaphor/analogies and 8 of the references back to previous knowledge followed student questions. (This may be taken to emphasize their role in explanation, rather than presentation, of ideas).

(e) During the lesson there were 12 short breaks or digressions e.g. the students would be told to relax for a minute while the teacher cleaned the board or, before going on to a new problem area, he would 'reminisce' for a minute or two. Although interspersed throughout the lesson, these occurred more frequently in the second section.

(f) Interspersed with (e) and again occurring more frequently in the second section, 12 jokes were interjected during the discourse. (These were generally well-received although a few groans would be mingled with the laughter).

(g) During the lesson there were 6 checks on individuals' work ranging from comments on individuals' homework to the teacher going round the class, while they were drawing diagrams, answering individual questions or checking with particular students that they understood so far. Very regularly and frequently throughout the lesson, the class as a whole would be asked if they had understood or if there were any problems.
5.2.2. INTERPRETATION OF DATA FROM CLASSROOM OBSERVATION

Although the lesson involved the imparting of a great deal of information from the teacher to the students, one predominant feature of the teachers style was the degree to which the students were actively involved in the lesson. He encouraged or instigated general discussion of phenomena, elicited references to previous studies or general experience and generally used techniques which encouraged students to work through and think about problems, (see b,c,d,g in 5.2.1.). Therefore, although this lesson could not be subsumed under the traditional use of the term "discovery learning", neither could it be categorised as "the spoonfeeding of pre-digested materials" since the students appeared to be expected, and to expect, to contribute to the lines of reasoning and argument.

A second feature of the lesson is the degree of informality and personal disclosure by the teacher. This is indicated by the main frame of language use, jokes, personal anecdotes and reminiscences. In contrast to this is the frequency of summaries and notes worded in the formal language of science (See particularly (a) and (d) in 5.2.1.) This is suggestive of two main ideas:— (i) that the teacher sees the formal version as in some way uncondusive to explanation/understanding and (ii) that he also concedes a requirement for the formal version to be known, recognised and used in particular contexts.
Another major aspect of this teacher's style is the frequent repetition of material, usually by means of a variety of modes of presentation for each section of material. These different methods seem to fulfil three different, although by no means mutually exclusive, functions i.e. (i) to teach techniques and to impart information to use to pass exams; (ii) to help understanding of these techniques and information in terms of derivation and application and (iii) to interest and entertain the students. In addition, these methods indicate the teachers acknowledgement, at least in practice, of the points derived from educational psychology theory about (a) repetition and its usefulness for memory; (b) individual differences in preferred explanatory forms and (c) limitations on attention span for new information.

From the observer's viewpoint, the style appeared to be natural in that the teacher seemed at ease and comfortable while the students similarly gave no indication that this lesson was in any way out of the ordinary for that teacher and subject.

Finally, the impression was gained of the lesson being well-planned from the observation that all of the OHP transparencies, handouts and demonstration equipment were to hand, while the topics and areas which were stated as its constituents at the beginning of the lesson were indeed covered in the allotted time. The teacher did occasionally check his lesson notes during the lesson.
Two samples from the lesson are included as Appendices II a and b - the first being an example of the initial analysis, while both act as examplars of the teachers style described above.
5.2.3. ANALYSIS AND INTERPRETATION OF GRIDS

For Grid 1 - "Role as a Teacher" (See Fig 2 overleaf) the elements were: (1) "to pass on or communicate information" and (2) "to build patterns and concepts" which were closely linked and suggest the teacher as the active party in the teacher/student dyad; (3) "to develop a scientific approach or way of thinking in students" and (4) to "develop communication skills" which again were closely linked to each other and suggest a more active part for the students. Element (5), "to kindle an interest in science outside the classroom", which suggests a more equal distribution of active input from teacher and student, falls outside the main cluster formed from the linking of subcluster (1) - (2) and subcluster (3) - (4). The suggestion here would be that the main cluster forms the core of Mr. A's role as a teacher, whereas (5) is a useful but not strictly necessary adjunct.

The constructs formed three main clusters. The first contained "easy to test if teacher effective"/ "less easy to test if effective" and "relevant to student exam passing"/"less relevant", which were very highly linked and both concerned with external, more objective assessment. The second cluster contained "would like to spend more time on"/"satisfied with time spent on" and "think I do most effectively"/"less effectively" (these being linked at the 100% level) "easiest for me to do"/"less easy for me" and "opportunity lent more for this in theoretical sections". These first two clusters were more closely
related with each other than with the 6th construct "takes up more class time"/"less class time". This suggests that Mr. A would like to spend more time on those things which he both finds easiest to do and feels he does most effectively. These also tend to fall into the more theoretical part of the syllabus and are more externally assessable. It is interesting that these are only loosely related (50%) to the perceived actual amount of time spent on them, relative to their converses, in the classroom.

The first grid was small and tends only to give a very superficial or generalised idea of this teacher's view - the elements and constructs chosen appear to represent what the teacher sees as what is traditionally expected of a teacher since, as the grid discussion evolved, ideas of a more personal nature became apparent (see interview and grid discussion Section 5.2.4.)

While thinking about the elements for grid 2 (Fig 3) "Teaching Methods Used" Mr. A made the following written notes for himself.

"Information is given by (1) board/OHP, (2) handouts, incomplete notes, (3) dictation.

Explanations given by (1) verbal, (2) models (3) diagrams, (4) practicals.

Verbal explanations could be (a) examples, applying information, (b) other words - simplification, (c) metaphors and analogies -
all of which would involve or would be involved in Question and Answer sessions. Practicals are designed to: (a) reinforce theory, (b) apply information, (c) give information but with different experience. Information is conveyed better if (i) they are happy, (ii) they like me, (iii) they respect the subject".

This indicated to me that Mr. A, by this time familiar with the grid exercise and therefore less concerned about the mechanics of its construction, could clearly order his thoughts about his teaching and had probably also given some thought to how he teaches prior to the exercise although he was unaware of the purpose of the grid and its nature in advance.

The elements were ten in number: "chalk and talk"; "anecdotes"; "metaphors and analogies"; "question and answer"; "individual help"; "student experiment"; "practical demonstration"; "solid model"; "data exercises" and "mathematical proofs". These formed three main clusters which finally became linked to the element "chalk and talk" at a much lower level of correlation. This suggest that "chalk and talk" may be a higher order category that subsumes the other elements - it may represent for him all that he does in the classroom. The clusters are all linked at about the same level and might be labelled (1) verbal-descriptive tools -"anecdotes" and "metaphors/analogies"; (2) checking
CASE STUDY 1 FIGURE 3 'TEACHING METHODS USED'

CONSTRUCTS

5: Takes more prior prepar - Takes less prior prepar
3: Used more often - Used less often
1: Central for convey.info - Less central
2: Central for understanding - Less central
8: Enjoy doing most - Enjoy doing least
4: Students like most - Students like least
6: Builds empathy - Does not help empathy
7: Does not help respect - Helps respect for chew

ELEMENTS

D: All narrative
E: All verbal
d: Some narrative
D: Some verbal
e: No narrative
D: No verbal
understanding - "question and answer" and "individual help" (3) working on information in a practical sense - "student experiment", "practical demonstrations", "solid models", "data exercises" and "mathematical proofs". Within this last cluster, "student exp." and "maths. proofs" are less tightly linked than the three other elements.

An interesting point here is that these two elements could be seen as requiring less personal involvement on the part of the teacher.

The eight constructs elicited also fall into 3 main clusters. The first contains "takes more prior preparation/"takes less prior preparation", "used more frequently/less frequently" and "central for conveying information/peripheral". This cluster might be called "practical considerations": indication of what has to be done. This cluster is next linked to a cluster containing: "central for conveying understanding"/"peripheral" very closely linked to "enjoy doing most"/"enjoy doing least" and also to "teacher thinks students like most"/"thinks students like least". This might be called "emotional considerations" indicating that the conveying of understanding is what the teacher prefers to do and also observes that his students have a preference for. The third cluster, well separated from the other two, contains "methods which build personal empathy"/"which don't affect personal empathy" and "methods which least promote respect
for the subject"/"most promote respect for the subject", which is
also conveyed as a strong concern of the teacher in the
interviews, because to him, methods which promote one in the
positive sense detract from the other and vice versa while both
are seen as necessary to either conveying information or
understanding.
5.2.4. DATA AND INTERPRETATION FROM INTERVIEWS AND GRID DISCUSSION

1. Philosophy of Teaching and Learning

One idea which is expressed frequently throughout the discussions is that this teacher sees himself as "very functional in approach", "very pragmatic"; this he explains, means that his main concern is "to get them through the exams and give them a scientific training". This latter is defined by him as "the ability to think clearly and argue logically". Further, he makes it clear that "understanding" is a means of achieving this aim as opposed to "rote-learning" which he remembers from his schooldays:

"Obviously you've still got to have a certain basic vocabulary of ... facts BUT I would say that now ... I think in my day it was more ... it was termed rote learning ... now one can teach it through trends, gradations ... you tend to learn about the framework and you hang facts on it"

(INTERVIEW)

"It's unlikely that they will have to explain (gives example) in an exam, for example, but at least if they have got some idea it helps the understanding of the stuff that follows"

(GRID NEGOTIATION)
Another idea which comes over as a strongly held, because of the frequent examples and explanations in these terms which occur in these discussions, is that teaching and learning require that the subject matter is related to experience - either directly to that of the student or indirectly by the teacher's sharing of his own experience; relevance and salience is emphasized.

"I think that a lot of aspects of chemistry can be applied to everyday life, which I think is interesting and I think we ought to be aware of them and I think its nice whenever possible to bring in examples when you're teaching which they can associate with things they come across - you know, its NOT JUST an academic subject." 

(INTERVIEW)

"when we come to think like - corrosion of metals - you can look out of the window and say - have a look at that roof - that sort of thing."

(GRID NEGOTIATION)

Similarly, he often relates his teaching style to his own personal learning style and experience:

"now really I'm thinking of myself as a student".

(GRID NEGOTIATION)
"I'm into those sort of things for remembering - I spent more time learning funny rhymes and sentences than I did actually learning the facts - I found it helped me."

(INTERVIEW)

Both of these concerns about relating to personal experience are echoed in, and are congruent with, two other main themes which recurred in the discussion - (a) the importance of forming a relationship with student i.e. to create a dialogue and obtain feedback as an aid to teaching and learning and (b) the importance of personality in teaching and learning style.

(a) "the difficulty in the early days, in early weeks, is to get them to relax and - to verbalise to them - for them to make noises back - you've got to make them relax".

(INTERVIEW)

"I feel that if in some ways I can get the students not actually to like me but to accept me as not an old fogey and to accept that I'm interested in my subject - then they will be encouraged to put more effort into the subject."

(INTERVIEW)

"all the activities I do, I think affect our relationship in the classroom."

(GRID NEGOTIATION)
"you can go about it in two ways - there was a lady (gives personal description) who was HARD ... but she was SUPER and they looked up to her and they learnt because of that ... it's an equally valid approach - you've got to do what suits you ... there's no way I could read the riot act".

(INTERVIEW)

"you will have people with idiosyncrasies whether it be ultra good intelligence or lines or spots, whatever - it's covered by individual help in or outside the classroom"

(GRID NEGOTIATION)

"it interests me a lot as to whether they do actually take them (notes) raw, digest them, reproduce them ... whether they do CONSCIOUSLY change them to suit their own particular thought processes?...."

(INTERVIEW)

Although in general he gives the impression that he has thought out his approach to teaching (see grid 2) and is fairly confident that it is the right approach for him, he went into the some detail about his worries that sometimes he is too flippant; how he checks this out with a few of the more serious-minded students at the end of the year. The main focus of this concern seems to be that he may be undervaluing his subject to the students:
"self doubts about this in recent years as to whether I was being too flippant in order to make them enjoy it and therefore I was, er belittling my subject ..."

(INTERVIEW)

This links with his frequent indication that part of his role is to communicate respect for the subject:

"but they need to respect the subject - not to be in awe of it but its got to be a thing that stands out in its own right - its a valuable, or valid subject"

(GRID NEGOTIATION)

Another aspect which is a recurrent theme when describing why he does certain things or uses a particular style etc. is that he apparently sees a strong link between learning and interest and that it is his responsibility to cultivate that interest. This is emphasised by his many references to using a variety of presentation methods both within the whole lesson and for a particular topic:

"theres no way you can shovel chemistry at someone for an hour or for two hours non-stop without them turning off ... you've got to have a variety show I think"

(INTERVIEW)

"I try to make sure that they've got the information that I want down - but I'll ramble around that when I'm trying to

100
help their understanding ..... some practicals are designed to apply information .... its a different experience for them .... so you're using a different sense to get the information over".

(GRID NEGOTIATION)

Occasionally, throughout our discussions, Mr. A would mention educational theories about teaching and learning but the general impression he gives is that he sees "teaching" as something instinctive rather than learnt, although training courses may refine your style or give useful practical hints:

"teacher-training is an interesting exercise - it makes you think about your subject, it makes you think about methodology, psychology etc. but - at the end of the day - its almost a gut reaction I think - you can't change your style completely - but you TUNE it each year to the class"

(GRID NEGOTIATION)

"You've either got a method, whatever it is - and when I say method its not just the way you formally learn in teacher training, its to do with your body language, the way you behave, the words you use etc."

(INTERVIEW)

"teaching methods EVOLVE as a result of your experience."

(GRID NEGOTIATION)
Part of his style does seem to include the careful preparation of lessons, at least as a framework, which may be modified as the lesson develops.

"I've always got something to prop in front of me - I worry about the fact that all the topics have got to be developed logically and if I'm doing it off the top of my head one tends to miss things out - that's why I need a framework to work within - preparation means conscious effort - even if it is conscious effort in the class while you're teaching - you know - you think "Oh that hasn't gone over - how the hell can I explain it?" that's conscious effort"

(GRID NEGOTIATION)

"the way I see it is its main core has got to be through instinct, empathy - I'm not trying to decry an education course but I see it as putting icing on the cake ... I don't think you can teach anybody to be a teacher ... not ANYBODY"

(INTERVIEW)

"I put a lot of thought into the communication process - it (the subject) could equally well be typing or cooking or whatever"

(INTERVIEW)

This last quotation also reflects a notion that the teacher emphasised throughout our relationship which links with the ideas
on "personalised" teaching mentioned earlier, that

"I teach PEOPLE, not a subject"

This was reiterated, with only slight changes in wording, in three interviews, on different occasions and in different contexts. During analysis of this data an attempt was made to classify this teacher within the model presented by Dennis Fox (1983) in "Personal Theories of Teaching" by using quotations from the interviews and grid negotiations. - see Fig. 4 overleaf. From this it can be seen that Mr. A seems to span the four theories proffered i.e. he uses both simple and developed theories about teaching and learning. There are two responses to this dilemma - the first is the teachers own emphasis, mentioned earlier, about providing a variety of exposition and different approaches suiting students with different abilities and needs, and the second might be found in the final paragraphs of the aforementioned article:

"It is not suggested that developed theories of teaching are always better than simple theories. There are many contexts where it is appropriate to prescribe clear-cut objectives and where there are straightforward generally applicable techniques for achieving them. It is suggested however, that a person who has reflected deeply on the teaching/learning process .... will be in a better position to choose the most appropriate approaches."

FOX 1983 p.14
5.31
3
MM

El 0

C)
m

M
m
0)

rt

El rt

C)
m
rt

I

I. A.

:3
Do

(A rt

rt
:r
M

0
Pil
0

0

0)

rt
r_

rt
0

rt

Ia.

1.4

M
0

0

00
rA

cr
pi

M 09
4M

M0

(D

m rt

1-4 0)

0)

I

ý-A W
M
91
a F3 0
5

cn

(D

I-h
m

.14
M
11

10
P-1
m

rt

1.4
tr
0
0.

v

14

:3M

ý-h

>

U)

t-A

Pr

tr

tri 0

H
pi
co

Z

tn

pil
M
0

rt
0

0n
m4 Z

00
0
.4
m

M
pi
rt

0)
r?
1-4
0

c3 po

CD
c71 1
ei ý<

rt
0

r:
0

H. 0
0
X , c:
mn
pl
Co :i
0.

ý"

c). (D

0

tr

Co H

0
m
rt
m
:i
rt

.m
I
L.J. M

tu

r_
rt

Cl.
a
(D -IJ

<

ki. 0n
cr
(D CU Cu

0Z
"
Ci.
zr
m
(D ca (D m
0 k(D
rt

h-a

0

l<
0
r.

f.1

0
0
<
)_A

0 >MO
Ei
fD

P
ft
1 H

=,
e
(D 0 rt

(D r.

CD 0

1.4
>"

cn
Z
cr
"
(D (D
1 (D
rt

re

(D

0
0 ci
ci fD
n (D
(b gl.
0

(P
>-&
0
10

CD
0
Pl

0

CD

1.4

10

El
W

43
CA
Ch
I.A.
:3
OQ

0

cu

(D

1.4
Mt

0

M

rt
V
(D

:i

I-h

MM
rt
34 :r
=1 (D
13
"

el
ý-&

(D

rT

"d

ý-h (A
0

0
0.
(D
CY,
0)
rt

:3
PV

2

0

ý-h

fA El
:r 10

OQ

ý- :3

0
?I
k4

ýý
10

0
r.

M
1--4
pi
0

rt

M.
M
0

ci

0
0.1
rt

rt
:r

(D

0

tzl
OD

W
(D
14
M

ca
zi
rr
m
0
92.

<
CU (D
pl 9»
k.
n

rt
t-

4
cu

rt
PV m

0
,3

rT
rt

0
f-h

(D
(D
92.
Co

0

C:
0.
CL M

(D

lu
, Ki

rt
0
rt

rA
1"th rt
Plh CD

S
(D

0

M
co
0
rT

cn

09

0

9u

rt

(D
0
rr

ß)

0m
V
:3

00

rt
:r
(D
0

: Z*

rt

rt

10

Q.
:
m aq
m

m

0

0
(D
a.

r»
rt
0)
:i
CL
Hzi

ý

rt

rt

rt
0

PO
Z

t21

0

.I

M
zr
cu
lii

:1

2 I-h

flT

1
92.

h.4
SA

MM0.

M
111

1
%<

iD
(0

%.10

M 0.11
0M0

0

c
0

Z

rt

0

rIp j
zr

09
Sh

i-m

10

09
0

'o
0 10 ?,1
(D 0

a

. 1 1--100
k-h r:

n
rý
rr bi.

,0

-%
tr

G) .

pi
rt

M
0

I-h
pi
0
19

ITJ

0
1:6
En

41

104


This teacher does convey a lot of personal commitment to teaching - a point which was raised in his final interview. His reply was:

"I ENJOY teaching - I do enjoy my job after 15 years of doing it ... the teaching part that is - not necessarily the ancillary parts." (teachers vocal emphasis)

From the data, this teacher's concept of "teaching" has much in common with his concept of "communication" - this will be explored fully under his views on language use: metaphors, analogies and anecdotes in particular.
Throughout the study involving Mr. A, he was generally fluent and willing to express his views on the topics broached. However, at least initially, questions pertaining to science - its nature, meaning etc. were quickly and somewhat superficially dealt with, sometimes with a degree of self-disparagement.

"I'm not a very deep thinker about chemistry"

(GRID NEGOTIATION)

"I am a very simple animal" (INTERVIEW)

This highlights his own accentuation on the second part of his job title "chemistry teacher" as mentioned earlier. Consequently, although in the final interview (when more directly confronted with my initial interpretations) he was able to confirm impressions in a more detailed and coherent fashion, most of the clues to his philosophy of science are derived from asides, or were by-products of other areas of discussion or were contained within descriptions of his own experience. In summary, he seems to see science as:-

(a) accumulated wisdom - he acknowledges "grey" areas but these appear to be gaps in knowledge rather than inherent in the matter of the study:

"I would accept that there are a lot of grey areas ... you can't explain everything ... presumably if ones goes on and on forever one is going to sort out ... the mystery of the
universe ... we are all working towards more and more knowledge all the time"

(INTERVIEW)

(b) requiring a certain kind of approach, viz; precise and logical:
"I see scientific training as the ability to think clearly, argue logically"

(GRID NEGOTIATION)

(c) requiring a certain kind of mind (mentalistic view of mind) and skills which define a hierarchy of ability in science, himself being about midway:

"there are your physicists/mathematicians ... they seem to attract the same type of person stroke mind or shall we say particular minds seem to be able to cope with these two best of all"

(INTERVIEW)

"I believe in "the mathematical mind" whereas I don't necessarily believe in a chemical mind ... I feel you need this little extra - this special spark"

(INTERVIEW)

"I reached a certain level but there are levels beyond that"

(GRID NEGOTIATION)
"we have scientists who are clear thinkers - who set .. the right syllabus, ask the right questions .. I believe that they are the ones that should set the pace and standards"

(INTERVIEW)

"for quite a large proportion of people it will be a waste of time because I don't think they would get much out of it" (referring to A level and beyond)

(INTERVIEW)

(d) divided into different disciplines, mainly physics (somehow superior because of mathematical orientation) and chemistry and biology - (the more practically-orientated areas):

"for the majority of people wanting to be scientists - then chemistry would not be the primary science"

"I think a lot of people would opt for chemistry rather than physics because of their mathematical background"

"obviously you can't particularly separate biology from chemistry"

"in so far as - our working lives and our products are tied up - a fair proportion are tied up - with chemistry and chemical reactions etc. it is PRACTICAL and I would have thought deserves respect on that basis alone - even before you start considering more aesthetic or theoretical type of things i.e. a training for the mind".

(ALL FROM INTERVIEWS)
This last quotation illustrates a theme which links these four main ideas together i.e. that science demands respect and that the teacher himself has a respect for the subject:

"it's got to be a thing which stands out in its own right - it a valuable or valid subject" (GRID NEGOTIATION)

"I do BELIEVE in the subject - I have become more impressed with chemistry over the last few years .... I can see clearly the place of chemistry and the importance of it". (INTERVIEW)

It would not be difficult to deduce that these ideas are derived from his own past experience for he reports that although he enjoyed physics more at school, he found that his mathematical ability would not support its further study and also that he found degree level chemistry and beyond itself somewhat a struggle.

This philosophy also has reflections in his teaching style and practice: empathy with student problems; concern for communicating respect for the subject and his willingness to relinquish the choice of syllabus etc. to "higher level" scientists.
A prominent feature of the discussions with this teacher was his general concern for communication. For him it appears that it has many facets which he elaborated on with exemplars in both interviews and grids.

He seems well aware that chemistry has a technical language of its own, recognising both that the students need to become familiar with it and that it sometimes presents difficulties for them:

"the early grind - the new vocabulary - learning to speak a different language almost "  

(INTERVIEW)

"You give them a set of notes and they think 'Oh, this is a load of PRETENTIOUS old whats-it' - I mean its actually true when it is scientifically couched - but this is it - you try to bridge the gap between everyday language and these fearfully concise, though well-thought-out - statements"  

(Teachers verbal emphasis)

(GRID NEGOTIATION)

"often all you're doing is using other words - you've given them a set of notes but then you try to put it over and break it down into simpler elements"  

(GRID NEGOTIATION)
These quotations also illustrate that he sees a need for him to simplify things in science for the students. It is interesting that he frequently used the metaphor of "breaking things down into simpler units" and "building up" the simple into the more complex, for discussing both communication and science. Similarly, "clear, logical thinking" is described as a necessity for both.

Another frequently addressed perspective in this area is the idea that individuals will interpret particular communications differently and he appears willing to take account of this in his teaching.

"It's not always obvious but when a student answers a question you occasionally see - a misconception or misuse of a particular phrase or expression"

(INTERVIEW)

"When giving handouts, or dictating notes, you are transferring YOUR explanation to the kids' minds ... If they write that out using their own phrases or expressions - providing it's saying much the same thing - it will probably be a more manageable package for them - cos obviously we don't all think the same or say it in the same way"

(GRID NEGOTIATION)

"It's interesting to get the odd students - it's refreshing - they will ask questions which make you think - 'am I being
too obtuse - I'm assuming that everybody knows and accepts this' - but of course it's not so - so one ought to be a bit more careful."

GRID NEGOTIATION

"I put a lot of thought into the communication process"

INTERVIEW

The last quote is representative of many which accentuate his perceived need to take care with the preparation and presentation of material and to allocate time, both within and outside the classroom, to this end. It is also worth noting, especially in the light of his feeling described earlier in relation to the mathematical aspects of science, that while talking of different kinds of explanations in the interview he says:

"the mathematical explanations - it's very apparent that it suits - pooh - the top 10,15 per cent - the most able students"

and in the grid:

"it's quite interesting - I see mathematical stuff as only appealing to one section of the class - always."

Another reiterated aspect of communication for Mr. A is that it is a two-way process - he also expects, and seems to receive, feedback from his students;

"There were more questions than usual - therefore it was important they were answered - even if it is often the same
student asking - I'm convinced there are other people with the same unasked questions" 
"question and answer - which is a 2-way thing - should be anyway - they should question as well as answer" 
"we had a bit of a debate - and laughed about it" 
"its an interaction really".

(INTERVIEW)

He also seems to be aware that there is a limit to how much information can be exchanged within a given period and takes steps to avoid overloading the students:

"verbal roughage - thats what its all about - I'm wittering on - learning curve against time, you know".

(INTERVIEW)

"there's no way you can shovel chemistry at someone for an hour or two hours, non-stop without them turning off"

(GRID NEGOTIATION)

Another concern which he emphasizes is that communication involves information to different senses, hence his use of alternative modes of presentation and the use of body language for emphasis:

"in my experience visual examples are easier to remember, and easier to understand but - the cautionary comment - how do they translate their visual experience on to paper?"

(GRID NEGOTIATION)

"effectively its a complete repeat of the lesson material except that you're doing it in a visual way" (INTERVIEW)
"some practicals are designed to apply information - it's a
different experience for them - you're using a different
sense to get the information over".

(GRID NEGOTIATION)

"it's a feeling - observation - body language"

(INTERVIEW)

This last quotation is an illustration of his own use of
different senses to receive a communication - in this case
"difficulty in understanding" - from his students.

Another feature of communication which seems of importance to
Mr. A. is its person-person interaction, especially that
involving some kind of enjoyment:

"information will be conveyed better - if they like me"

(GRID NEGOTIATION)

"My own addition gives them a bit of rest - and a laugh."

(GRID NEGOTIATION)

"I try to teach through - some humour if you like"

(INTERVIEW)

"I could almost do it by saying read pages x,y,z, in a book
or handout - whereas if you get into the sort of physical
aspects ...... they'll enjoy that very much because you can
develop it".

(INTERVIEW)
This teacher is well aware of his frequent use of metaphor, analogy and descriptive anecdotes and spoke about their use in general and about particular examples that he had used. His main ideas are summarised under various headings below.

a) when they are used: usually spontaneously as need arises in the classroom, although he has a "stock of favourites" which he knows are useful in particular circumstances.

"There's an awful lot that you don't think of until you get in the class - its just something that occurs - its not planned particularly".

"I don't, consciously think - oh - I'll tell them about that"

"When I've taught parallel classes the same topic I've told one story one day and another story another day" "you can't say that a section lends itself (to metaphor/analogy etc.) - it depends on your own personal experience".

"Your mind becomes programmed to them - they get built in to your lesson - you might have to hone it a little bit - knock it into shape". (ALL FROM INTERVIEWS)

b) Sources are: own experience and learning, others' lessons:

"I always compare things with my own experience"

"I sat in his class - I thought 'that's a superb analogy - now I know what thats about'".
"It's nice teaching a subject in parallel with someone else because one picks up their anecdotes as well".

"One trots out stories that are little bits of one's own history." (INTERVIEW)

c) Positive aspects perceived by teacher: as devices for remembering; as providing simple examples; as associations with own experience; as back up to formal explanations; for understanding and learning; for humour and variety; to promote interest; to increase personal empathy. These seem to be reflections of what he sees as "good" communication.

"A device for remembering a rule really - it's purely to remember - I'm into those sorts of things for remembering".

"I'm fairly confident - again from my own experience ... that they do remember the chemical fact as a result of that story"

"It's a simple example which anyone can grab hold of"

"A lot of aspects of chemistry can be related to everyday life"

"I quite like the idea of having them side by side (with discussion, practicals etc.) - I think one backs up the other".

"It's just that you're trying to make them understand - help their understanding - I found it helped me"

"They help learning and if they don't at least they're distractors - a way of making it interesting when you're teaching" (ALL FROM INTERVIEWS)
"its another way of presenting new information" (INTERVIEW) "you have to put it in the context of a 3-hour lesson with a short break in the middle" (INTERVIEW) "jollying them along" (GRID NEGOTIATION) "it adds another little bit of 'me' - they will be encouraged to put a bit more effort in". (INTERVIEW)

d) He is also aware of some disadvantages or limitations in use:
"you can get into trouble sometimes if you take your analogies too far"
"it can have a horrible pitfall - you start an analogy and then before you know where you are, you find its run away with itself and there's a lot of exceptions and contradictions which can be difficult". "the problem is I don't particularly plan analogies - whereas you plan a lesson - so if a new one springs to mind you may walk into a minefield if you're not careful - because of all the variables" (ALL FROM INTERVIEWS)

e) He has never tested if these devices work because he 'feels' they do.
"I don't have a questionnaire afterwards and say 'did you understand it more clearly?' because I FEEL it works" (INTERVIEW)
However he also indicates that he has discarded some which have proved difficult or had unforseen consequences.
5.3.1 STUDENT INTERVIEW AND WORKSHOP DATA AND INTERPRETATION.

GENERAL POINTS

(a) The interviews were semi-structured and open-ended in nature i.e. the interviewer has a basic set of research questions in mind but these are approached tangentially: to avoid bias; to allow students to speak as freely as possible, letting trains of thought develop; and to let natural preferences become apparent. This meant that the general order of questions was dictated by the students' responses. It also meant that some research questions were answered directly while others were answered in asides or during the elaboration of another answer.

(b) Although there were differences in degree of relaxation and ability to articulate ideas across the students during interviews, very few needed much prompting by way of extra questions. In general, they were prepared to elaborate on answers and in some cases it was necessary to allow students to get a lot of their thoughts and feelings (about education system in general, about particular schools and so on) off their chests before refining down to the main areas of research.

(c) More because of time-table limitations than willingness to answer, some interviews covered the research area in greater breadth and depth than others.
(c) Each student interview was analysed separately (Section 5.3.2.) and then the resulting data was co-ordinated (Section 5.3.3.)

5.3.2. Individual Student Responses.

In this section, each student, represented by code initials, is briefly described and then his/her views on (A) Science in general, chemistry in particular; (B) General teaching and learning; (C) Mr. A's teaching style - use of figurative language in particular, are summarised, each being followed by quotations which represent the views expressed.

STUDENT J.C.

Female student slightly older than rest of class - has Biology A level - little or no physics - wants to go to university to study biochemistry.

(A) Views on Science in General, Chemistry in Particular

Science is discovering answers to questions and more basic questions to ask - questions are restricted if theories accepted as facts - chemistry is more exact than biology, biology dependent on chemistry, increasing knowledge results in greater complication rather than a change in the picture.

"Science is just discovering why it is all as it is"

"Science is the investigation, study and putting forward of ideas of how this whole lot works, the world and beyond ...
... and the little bits of it ... and why it got there in
the first place"

"they (scientists) are getting nearer and nearer to the
initial questions, the basics .... slowly going nearer the
beginning .... how it all started .... finding out the ideas
and then applying them to things in the future .... I think
there's a long way to go".

"Things must not be put forward as facts if they were just
one of the many possibilities put forward .... things
accepted as facts are very difficult to question and change"

"As a more exact science, if I had to choose, I'd choose
chemistry of living things .... it fits in well there ....
I've always seen them as separate because they are always
presented that way .... only when you get to higher levels
that they start joining together .... biochemistry .... I
think they go well together - you can't do one without the
other .... you certainly can't do biology without the
chemistry"

"So it hasn't changed it has just become more complicated -
the picture remains the same only you are a bit more in
depth".

(B) Views on Teaching and Learning (General)

Preferences to understand things, see relationships - has
difficulty with rote learning - sees 'explanation' as
intrinsic to learning, as is concentration on topic rather
than presentation (writing styles etc.).

"I would say the organic is harder - that's because of the sponge-learning - just learning facts as facts .... miss the basic differences between things .... but it is .... the sponge-learning .... which just bogs me down".

"I'm beginning to understand roughly why equations are as they are - before it was just a matter of using them".

"different energy levels .... that was totally new and he explained quite a few things which - I didn't have a clue about before".

"We used to have all .... the formal school bit .... there was more emphasis on the English, on writing the chemistry up, than on the chemistry itself - its a great burden removed, concentrating on the chemistry rather than on the English."

"I prefer a non-mathematical way - if I think I understand something, and I'm really making sure, I do go through the sequence in my head explaining it to somebody else .... I practised it on this imaginary person and it works out quite well, so I do tend to do that to make sure I understood".

(C) Mr. A's Teaching Style - figurative language in particular.

Personal, relaxed, concerned style in teacher motivates students; class involvement and jokes aid concentration; metaphors and
analogies, which may be amusing, dramatic or relating to everyday life, aid concentration, memory and ability to work out things from basics and are referred back to frequently.

"Mr. A - who is probably the best teacher I have - he moans if you haven't got your homework in, it does actually hit the mark I think".

"It's really because he makes a special effort for me - I feel - if anything comes up - that I don't know - he makes sure he tells me - so I don't panic. So he's going out of his way, and ... if I don't do the work I feel awfully bad ... I've let him down ... he's working hard for me, so I do make a bit more of an effort".

"there's a personal element that makes a difference .... encourages you to do well .... it's fairly casual but people are only going to take advantage of it if they don't care anyway - so I think the works get done even though it's pretty relaxed".

"it makes the lectures more interesting as well .... you certainly don't fall asleep .... class participation, a few jokes, keep you alert and the actual stuff - the teaching - sinks in well".

"the little stories are for one a lot more amusing and tend to stick - we'll never forget the surface area of fish fingers in batter, I do think (relates story) - little stories like that help you to remember".
"the mathematical ones (explanations) .... I can't see them - if they're joined in with (a practical example) then they CAN make sense as well"

"anything a bit dramatic sticks, anything you get - a laugh out of .... relating things to everyday life .... going down to the layman's level .... might not be so accurate but it certainly sticks better".

"if you can't quite remember the details you can work it out for yourself if its put in everyday terms".

"(Gives an example of analogy) little stories like that do work because even if you have forgotten .... if you forget the facts .... back to the sponge learning which I'm not very good at .... you CAN work it out from the everyday analogies".

"yes, I do feel I remember the analogies and use them again and again"

"in the more complicated things its nice to be able to work it out from the basic principles again - be it using a twig or a fish-finger".
STUDENT N.C.

Young female student studying biology, chemistry, physics A levels - says pushed into science by father - "science is the future" - interested in marine biology as a career.

(A) Views on Science in General and Chemistry in Particular

Has a preference for the down-to-earth and logical - likes to get a right answer. The sciences are clearly separated.

"I see physics as the hardest but its different kind of difficulty to chemistry...."

"the physics is more down to earth sort of, there's a right and a wrong .... you either know it or you don't its more mathematical, whereas you can have several different things in chemistry giving the right answer ... for the same thing".

"you get more satisfaction out of knowing you've done your physics right".

"I liked that (thermochemistry) .... I think being able to work out the equations to actually get your heat changes and things like that for the reactions and .... its all very logical it much easier to follow through I think. I much prefer the physical side but thermochemistry is definitely my hot spot (laughs)!"

"(structure of atom) it pleases me actually, I find it very logical and I like it".
Concerned by alternative explanations given at O level from A level — concern with being told the "right thing". Tendency to accept what is offered. Confidence comes from knowing more information.

"... the teacher who was saying — alright we lied there, you know things like that — it's a bit off-putting actually .... I mean you like to know that you are being told the right thing — you took that in confidence then — perhaps it makes me think now if .... they're telling you the right thing but you learn it because it's what they're giving you and it's what you need to know".

"it's a different concept altogether I know but I .... I just take it really".

"I was very worried to begin with, sort of took down the notes and thought ooh goodness, went back home, looked at the notes he'd given us — they were fairly comprehensive and I could get through it".

"I'm a bit hesitant with my chemistry because I know so little .... I'm sure if I knew more, um, you know, learnt a bit more .... which I'm trying .... then more would come out".
Finds style helpful - figurative language helps to make the abstract more physical, pictorial - perhaps for confidence building - interest is helped by greater understanding.

"... it was more sort of getting over the barrier of my own saying 'you can't do it,'.... I think it has a lot to do with the way he teacher it to us cos I think he's very good - gets it across quite well".

"(reference to particular analogy) yes, I thought that was good .... it brought it all together in a sort of physical .... more sort of picturesque so you can understand it rather than .... having to worry about them as individual bits"

"(use of metaphors in general?) I think its, um, its much .... it brightens it up a bit more and instead of using .... you know a sort of special term of chemistry he uses say 'log jam' .... it breaks it up .... brings it all back .... and helps you visualize a lot more".

"Yes, .... (more interesting) .... cos you understand more of what you're being .... whats being said to you".
STUDENT G.T.

Male student retaking chemistry, maths and physics A levels - wants to study science at university.

(A) Views on Science in General and Chemistry in Particular

Fairly practical view of science - its about thing you can see, manipulate, etc., and everyday life - provides explanations, answers, rules - chemistry best of sciences for this - dislikes "fuzzy" theoretical side - better equipment at higher level gives more answers which are there to be found.

"its easier than something like maths cos maths is a lot of thinking and chemistry .... has got materials which are actually there .... there's nothing sort of hazy about it .... when you get to physical chemistry .... things like looking inside the atom .... it gets sort of dodgy .... but there's mostly things you can see and touch and make .... its actually something you can-to grips with so - its a science .... of .... things which people can easily see".

"I think it mostly very closely related (to everday life) .... to see what the reasons behind it are"

"(chemistry) its better than other things cos in other things you can wonder why then you can never really get an answer but chemistry can .... usually get some way towards it."

"its easy also its sort of like a jigsaw or crossword."
(B) Views on Teaching and Learning (General)

Preference for solid models, demonstrations, practicals, worked examples. Dislikes theoretical side, sees it as unreal - needs broad overview first - to know 'the answer' before going into intricacies (holistic approach). Prefers friendly style which produces self-motivated learning.

"(get most understanding from) the models .... like you know they've got these - polystyrene ball things .... so that you can grasp them (gives marbles demo example for activation energy) .... things like that you can see .... mathematical ones .... I can follow maths - but although I can follow the workings of it .... its just something on paper really .... its not real".

"Demonstrations are good .... and I like doing those worked examples .... its the thing that really helps .... I enjoy doing it .... its good fun .... working something out", "going over and over .... labouring the point so much .... by the time you've laboured through to the end you've lost sight of the beginning .... sometimes I wish .... he'd sort of get to the point relatively quickly and then sort of explain the fuzzy bits in between rather than go slowly through each but - cos you don't really know what's going to happen next - the summary is what you should have in the introduction"
I'm not going to be .... sort of larking about - not listening
.... they are much more friendly the teachers .... they are not impersonal .... they are actually talking person to person rather than teachers talking to a class .... its just you can get along happier".

(C) Mr. A's Teaching Style - figurative language in particular

Friendly style allows for discussion and for problems to be aired; figurative language useful for introducing new idea, giving a pictorial/visual image which is necessary but can be oversimplification since it is not real, therefore not much aid to understanding but aids lesson by adding interest and amusement.

"He's more like - a friend - explains it rather than someone .... yelling at you, calling you thick or something .... which is sometimes what happens .... cos it gets a bit more sort of like a group discussion - everybody can put in their ideas .... or you know, their problems."

"(figurative language) its something you can imagine although it seems a bit silly .... to imagine .... electrons stuck in to a plum pudding or .... making finite edges like a doughnut .... but its something .... I suppose its something you can grasp"
"you can't really do without (a visual picture) .... you can't measure it or draw it .... and even though you know that the drawings .... just really stylised .... at least you can imagine .... something .... although it doesn't really .... you're just sort of approximating .... its not that satisfactory but .... er, its the only sort of picture you can have even though for all you know it may not be right".

"analogies .... everyday language .... if you do too much .... it just seems - like its not really chemistry at all .... sort of made too easy .... oversimplified .... its not realistic - although you know occasionally .... it can help .... but if you did it all the time I imagine you sort of .... losing sight of what you're actually .... investigating."

"it doesn't make things MORE difficult but doesn't make them easier .... just makes you giggle a bit .... I suppose they do actually - (help your interest) cos otherwise it would or could be just one sort of drone ... I suppose in that way it does help .... it livens it up .... if it keeps you interested then you're likely to listen more".
... you can work out what's gonna happen ... sometimes gets a bit Sherlock Holmesish ... you're trying to work out ... and then you can actually DO it and then find that it does actually work" ... cos there's an answer to it as well — rather than just wondering about it".

I don't like doing the inorganic because there's so many things you gotta learn ... organic chemistry is really good because it all goes round in a cycle and it ... and you know definitely that if you react an acid with an alcohol you get an ester ... you can follow it round in tracks ... but in inorganic ... there's no sort of rules to follow it round."

"but the ... covalent bonding ... I don't really follow ... I can accept it ... and you know ... learn it ... but I don't really understand it ... how they can tell ... I don't know how they could have worked it out in the first place."

"(higher level chemists) I suppose they aren't any different than I am, I suppose they're just as puzzled really but they've .. the higher up you get the better equipment you've got to .... suss things out really."
STUDENT M.D.

Female student taking chemistry, maths and physics A level - hopes to study medicine.

(A) Views on Science in General and Chemistry in Particular

Prefers physics, sees it as applicable to everyday things, and biology - more common sense than chemistry - which is composed of rules and rote learning.

"Chemistry - its all rules really, you've got to do everything in a set way, whereas .... biology is more common sense .... and physics .... I think physics is the best out of the three .... you can apply it to everyday things all the time."

"all the first year organic - I think thats easy then again - either you know it or don't know I think".

(B) Views on Teaching and Learning (General)

Prefers understanding to rote learning and sometimes has difficulties with deduction from material learnt that way.

"I find that if I understood something then I don't have to learn it if you see what I mean whereas when .... its things
I don't understand .... you sit and you learn and you learn
and you learn and you just don't KNOW"
"the second year organics .... its alright to learn it but
then .... we get those questions where they give you all
these compounds and say A is this, B is that, C's that and
you've gotta .... put .... say what they are and I just
really am lost"
"and when you don't understand you just switch off"

(C) Mr A's Teaching Style, figurative language in particular

Appreciates the efforts put in explaining for understanding -
friendly informal style makes for approachability of teacher -
figurative language sustains interest and aids memory -
"masculine" metaphors cause no difficulty because this type is
frequent in science.

"I mean he explains things a lot more and you go into it in
more detail and you think - that probably explains why at 0
level they said that - and you just accepted it .... now you
understand WHY and that is good"
"everybody's more interested and .... we all know that we
can go and chat to him afterwards .... he's a nice teacher
.... sort of jokes around"
"it keeps it interesting in the class anyway which is a
good thing"
"when they come out with their little stories about this, and the other you always remember them".

"I thought it was a good one (particular metaphor) because he .... sort of relates it to people in the class .... and you remember more .... he and we snigger and laugh and you remember it".

(Male sporting analogies and metaphors) "you get used to them because - like physics everything is related to cars and cricket and golf .... you get used to it after a while - no' problem".
STUDENT C.A.

Male Army-sponsored student studying A level chemistry and biology for promotion as lab technician.

(A) Views on Science in General and Chemistry in Particular

Prefers biology in that it relates to things you can see - sees chemistry as highly theoretical, unproven, - too abstract.

"I prefer biology .... the thing I don't find very interesting about chemistry is when they start talking about electrons and atomic structure - all that bores me a bit but BIOLOGY - its all related around you and you can actually sees things .... its much easier to understand than chemistry .... a lot of chemistry is just a load of theories which haven't actually been proved - (scientists) they don't know everything".

".... abstract ideas .... I don't really understand them too well .... I prefer the practical".

(B) Views on Teaching and Learning (General)

Does not like intellectual explanations - prefers physical proof - likes to see for himself.

"when they're just sort of talking about theory and
explaining it in an intellectual way .... I'm not too sure about what's going on"
"I need - physical proof, I think .... when we have some theory lessons, they're talking about all these reactions that go on, I like to see them, to prove to myself that they actually work .... because I don't accept everything that's said to me as being true".
I'd prefer more - physical evidence than theory .... although previously people have done that and it's been passed down in books .... so they take it that it works .... I'd like to see it for myself"
"it normally sticks in my mind when I've actually seen something done."

(C) Mr. A's Teaching - figurative language in particular

Finds them enjoyable - breaks monotony of things, helps with memory.

"I enjoy listening to that sort of thing - I find them enjoyable and useful .... it helps to remember the rules .... I seem to remember most of the little stories .... it's mainly the story that sticks in my head - but it can help with the theory"
"I think I'd crack up if it were just lectures - I prefer the stories - it breaks up the monotony of the lesson - puts a bit of light humour into it".
STUDENT A.B.

Male student. Resitting A level chemistry, maths, physics - plans to go into civil engineering - "pushed into it really by my O level results"

(A) Views on Science in General, Chemistry in Particular

Concerned with practicalities - both in choice of subjects - what he uses science for and also what he sees science as about - appears less interested in abstract ideas etc.

"I like learning something different in the sciences - (chemistry) not as important as my other subjects .... its just a matter of having 3 sciences - well - 3 science related subjects together".

"I see the physical sides of chemistry and physics to be quite similar - you can relate to both - but I think the organic - its just a matter of learning the chemistry - you can't really relate it to anything."

"it (science) has helped me to understand a lot of things I didn't know before .... if I see something on tele which they are talking about .... I can understand what they are talking about which relates to chemistry".

"the very advanced science - I think it is making progress - throughout - creating, say, new televisions for instance"
(What about discovering the nature of the world?)
"I think they've gone too far already .... I like more of an air of mystery."

(B) Views on Teaching and Learning (General)

Prefers to "learn" clear cut material - has difficulty with "working out" and concepts - stress on benefits of being responsible for own learning but having rapport with teacher, or personalised teaching.

"for the organic .... I think its more clear cut than the physical and so if you learn it then you know it really down to scratch whereas the physical's sort of going through your mind all the time .... having to work things out .... which I find tedious .... I think its the different concepts more than anything else"

"I can visualise it but I can't actually put it into words"

"before we just had one teacher and I found it sort of interwoven and getting mixed up with all the different subjects .... with having different lectures for the physical - that sort of defined the subject all by itself - it seems to help me a lot more"

"(my old school) was quite strict and you're told to sit down and learn - being TOLD to do it .... but I think here being a lot free-er and being on your own - you know you've go to do it for yourself - I think its a help really - more freedom"
"but I think the lectures here do actually relate to the person .... the different people they're teaching .... more individual attention and sort of gets you an idea of the lecturer".

(C) Mr. A's Teaching Style, figurative language in particular

Prefers personalised teaching style, explanations which relate to his experience and aid visualisation and memory.

"- (see last quote above) -"

"prefer (explanations) relating to things which happen to me in my life - it does hold the interest more I think"

(particular analogy) "You could visualise it straight away then .... you know .... you could actually SEE the thing bending".

"I think its easier to understand, you can actually see what's happening .... like he said bending the twig - when he'd said anything about the double bonding then you could SEE it".

"(later - other occasions) I'd use the story .... then you can work something out (from it)".
STUDENT R.S.

Male student studying chemistry, physics, psychology A level - chose science under parental pressure - interested in Environmental Science degree.

(A) Views on Science in General Chemistry in Particular

Chemistry is a back-up subject, something separate from the normal world around. Preference for the organised, systematic and tangible. Stresses ideas about 'proof' and acceptance of the 'proven'.

"I was into physics consequently I had to do chemistry as well .... I've got a basic sort of interest for chemistry but not what you'd .... its not my science .... I now look on chemistry as a means to end"

"whenever I see something happening in the world I don't go round sort of equating it with science facts".

"in a broad sense organic chemistry is more easy than physical or inorganic .... because there's basically more .... its more systematic .... its organised".

"if you've got two sets of proof - then you know you've just got to accept it .... if you can accept that then you've got no real hassle but .... its a very difficult topic because you can't see it, you can't feel it, so basically you've got no choice but to accept other people's arguments ...."
"... you've just got to accept if one person is saying - I've got proof of this - I think its right and another person is saying I don't have proof of this but I think my explanation is better then obviously you'd go for the one with the proof .... BUT if they are both saying I've got equally good proof then the only thing you can do really is just sort of accept both ... its just exactly the same thing in theories of the electron except .... both of them are and have been proved to be true".

(B) Views on Teaching and Learning

Transmission of knowledge - teacher-stimulated interest - stress on relief of boredom by variety of presentation and informality; importance of good relationships.

"thats what the whole concept of teaching and learning is based on .... other people passing on knowledge that they've learnt to other people"

"if you had the basic interest in the subject then you'd be O.K. because you could work on your own without guidance, but if you didn't .... and he (the teacher) wouldn't or couldn't do anything for .... that's what I call bad teaching"

"the more variety you can get in a lecture the more you DO take in .... a mixture .... to alleviate the boredom (of a 3 hour lecture) they really help I found ...."
"I think I learn more from informal ones than formal ones (teachers)".

Mr. A's Teaching Style - figurative language in particular

Emphasis on variety of explanation, especially non-chemical - making the abstract pictorial for understanding and memory; entertainment value, - less boring.

"Anything that, it sounds really odd, but anything that takes your mind away from chemistry is bound to make the chemistry sink in .... it sounds a fallacy but .... anything that brings chemistry you know down to the human level is bound to make it sink in .... especially in the sort of field .... where it is difficult to visualise what is actually happening .... anything which helps that - like analogy - the sea - level one- I found that quite helpful .... and as I say the entertainment value helps quite a lot". "You can't describe anything totally with models or totally with maths, you've got to use all three (i.e. maths, models, analogy/metaphor)".

"I believe Mr A. is into rugby .... and I think in some lessons he's resorted to the odd rugby analogies, quite apt I think that one was (specific reference) .... I don't think there are many people who DON'T know what a try, or a scrum is or whatever, but for those who do it is very apt."
"if it were very apt and sort of a really good analogy I might think in passing well - that's O.K. - I remember it that way …. but if you use it to learn actual basics …. the theory …. then you've learnt the theory and there's no real problem relating it to different problems and …. those …. mnemonics, they always help".
STUDENT K.L.

Male student. Has chemistry, biology maths A levels - resitting chemistry to do pharmacy at university.

(A) Views on Science in General, Chemistry in Particular

The three sciences are interrelated - back each other up - prefers to think that "top" scientists know all the facts - has little time for practical aspects except for exams etc - prefers theory.

"chemistry is useful with biology because it helps you to understand other things .... some of the physics comes into chemistry - if you didn't know physics to 0 level you might have a bit of a problem"

"(I'm) not at all happy with the idea that top scientists don't know all the facts".

"(practical) I think it kind of highlights the points that we make if we go through the theory .... I don't use it to understand the theory I don't think .... I might use it .... for various calculations .... I really see it as a means to getting the exam part of it out of the way rather than helping with the theory".

"I don't think it really affects the theory .... so you could be really good at the theory without .... the practical being stressed so much if you're not really good at it".
Teachers should be encouraging, explain well and provide variety and flexibility. Learning by rote is easy - understanding "why" is hard work - learning and enjoyment are linked.

"I really went into A level a bit fearful - my (earlier) chemistry teacher .... wasn't one for encouraging pupils so I went in thinking I was going to be really bad .... I actually started ENJOYING it in the exam".

"I think you're going to have to change it (teaching style) for different people, some people are just really confident and you've got to kind of bring them down to get them to work for you and other people are really worried about it" "the easy ones are .... its just a question of learning like reactions" 

".... it gets very hard when you have to learn WHY, thats what I find hard .... organic I enjoy .... probably because I enjoy it I'm willing to work at it .... its better just to reel things off .... it depends a lot on the teachers as well .... if the teacher really explains it well then it shouldn't be that difficult to comprehend and its just a question of going through your notes a few times".

"if its really boring I get fed up .... fall asleep .... if I actually enjoy going to a lesson I find I work a lot better than if I don't .... if its just somebody talking
all the way through I just can't concentrate all the time, I just drop off"

(C) Mr. A's Teaching Style, figurative language in particular

Feels Mr. A's style and methods give him confidence; likes repetition, figurative language, particularly if funny, makes topic and whole lesson more memorable.

"I think Mr. A's method of kind of ... he doesn't make you think you're ... kind of the smallest member of the group"
"he's always going through it again and again so you think - well I understand this, perhaps someone else in the group doesn't .... I think its good .... makes you feel quite good about it".

"the analogies .... especially I've found if something's funny or stands out in the lesson .... I remember that without you know - looking back .... I mean it just stays in my mind something like that .... it depends on the analogy .... some of...just kind of reminds you of that topic - others - yeh - you remember the whole of the lesson a lot more clearly .... sort of .... you remember the joke or the story and then the rest afterwards".

"its quite good .... everytime I see a double bond I think of (that analogy) .... so it sticks in my memory .... stuff like that".
5.3.3 GENERAL RESULTS OF ANALYSIS OF STUDENT INTERVIEW DATA

(A) Views on science in general:

Out of the eight students studied, seven stressed ideas about science in terms of it being organised, logical, practical, down to earth; concerned with facts and providing the 'right' answers. The eighth student also mentioned that science discovers answers to questions and that if information is accepted as 'fact' it restricts enquiry.

(ii) Views on chemistry in particular:

Three of the eight tend to see chemistry as being an abstract, theoretical science whereas the remaining five see it as being practical and concerned with everyday life.

(B) General Views on teaching and learning:

(i) five students specifically mention good teacher/student relationships and/or a friendly teaching style as being important to learning; four students mention self-motivation, as opposed to 'being made to learn', as important; another three students strongly imply that learning is a teacher dominated activity in that the teacher SHOULD motivate and interest students.
(i) Half of the students preferred rote-learning, being given information and disliked "intellectualising" whereas the other half preferred to work from first principles and gain understanding, disliking or having difficulty with rote-learning.

(C) (i) Views on Mr. A's Teaching Style

All of the students made positive comments about Mr. A's teaching style as an aid to learning and described it as friendly/personal/relaxed. The ways which they found it useful varied: one student found it at least entertaining and not 'bossy', while three students mentioned his approachability and three felt that his style built up their confidence and finally one specifically mentioned that the teacher's obvious concern for them motivated the students to work. A majority of the students also made reference to the teacher's frequent sharing of mnemonics etc. as devices to aid memory.

(ii) Views on the use of figurative language:

Six students specifically mention that it is useful as a memory aid; six students specifically mention its use for adding interest and decreasing boredom; four students specifically mention its use for aiding visualisation and pictorial image-formation; four students specifically mention its use for relating the new to previous experience; three students specifically mention its use for helping understanding.
Although all the students could see at least one advantage in using figurative language, the two older students mentioned disadvantages i.e. they may not be such accurate explanations (J.C.) and they can cause confusion by oversimplifying concepts (G.T.)

All the students seemed familiar with the particular figurative vehicles used and, in the class, the female students seemed to have no problems when the vehicle was derived from male activities such as sport (e.g. rugby).

A check was made comparing students' views on science and views on teaching and learning with their views on figurative language use but no regular pattern could be found in this small sample except for the following. Two of the three students who had a preference for abstract, theoretical work made no mention of its use as an aid to visualisation, but both thought it an aid to memory, while four of those five who preferred practical, down-to-earth subjects mentioned that figurative language helps them to visualise abstract ideas. Finally, each student either mentioned that figurative language was an aid to memory, or said that it added interest to the lesson or spoke of both of these advantages.
5.3.4 STUDENT WORKSHOP DATA AND INTERPRETATION

The samples of figurative language used for discussion in the workshop, together with the notes made on them by two of the students, can be found in Appendix IIId. These samples came from classroom observations of several teachers and in this workshop the students recognised those which had come from their own lessons, and could recall the context. This lends support to the notion that figurative language acts as a cue to memory both of the concept being described and the context in the lesson as a whole. The students' perception of this idea is discussed later in this section.

During the discussion of individual metaphors and analogies and the general discussion, there was an almost equal mention of their use for forming pictorial images (12 comments); for memory aid (11 comments); and for understanding (10 comments). These figures cannot be taken as having any other significance than that the students generally recognise these properties, particularly because it is difficult on occasion to decide how the students differentiate between using it to form mental pictures or using it for understanding e.g. "I get the picture" - "I see it now".

As a rule of thumb, comments along the lines of "I can picture it in my mind" were taken as visualisation, and those such as "I
see the point" were taken as understanding.

The discussion began with the "Solar system atom" and was indicative of how some metaphors, by their frequent use, became part of the general way of conceptualising some ideas:—

(All quotations are from students)

"It's the way you think about them in chemistry, the way we've always been taught anyway".

This then led to a discussion of such models which centred around several ideas:—

(1) simplified/inaccurate models are used in initial stages of a subject;
(2) these are gradually built on;
(3) simplification is acceptable and sometimes necessary but should always be signalled.

"When you first start doing chemistry .... yes it's accurate enough then."

"With models, you get given the initial model and at every stage you develop .... yeh, you make it to suit the needs at the time, you add more and more stages till you get to the reality".

"I quite like it because it simplifies, strips away the extra bits".
"the problem is that it implies (example quoted) - so its not completely accurate".
"I don't mind if they SAY this is a simplified view .... I don't like it if they don't".
"I do wish they'd say about the time they taught it .... rather than a year later when they want to revise the subject".
"rather than us accepting such nonsense for so long".

Simplification in terms of personification caused lively discussion and signalled the differences between students and their preferred learning styles and world views.

"I think this discussion is dividing into two groups of people - the one group that calls their cars and machinery names and the other one that doesn't"

These differences between students became more clear as the discussion ensued. These divisions centred on:-

(a) differences in past experience which could limit the applicability of a metaphor or an analogy;
(b) differences in how literally a metaphor is taken;
(c) differences in how far they are generally pushed by each individual student;
(d) differences in whether they are discarded or retained once a topic is "learnt";
(e) differences in preferred modes of delivery of metaphors and analogies.
(a) "I thought this was a bit obvious"/"I was a bit puzzled" (One student familiar with vehicle and able to describe it well, the other not familiar with it).
"You have to know the song to understand it"
"I thought of it like the biology"

(b) "I keep thinking what about the stalk - I can't incorporate it"
"if you had an absolute block, if you kept on seeing seashells it would be a puzzle"

(c) having all agreed that one particular metaphor was really good, one student pointed out "yeah, but the man could be running faster .... you'd have to say he was running at the same rate".

S1 - "I thought - it was alright"
S2 - "but what if you take it to its logical conclusion ....?"

(d) S1 - "Yeh, discard it"
S2 - "it depends"
S3 - "sometimes you still go through it".

(e) See "timing" below.

The importance of the context of the delivery of figurative language was also highlighted in the discussion:-

"unless he sort of said (....) and didn't qualify that then I wouldn't really understand what he meant .... but with the other explanation it can make sense."
"if you take a sentence out of context there may be images there that the teacher didn't intend but if you take it within what the teacher's been saying for the last 5 minutes it might not be so bad".

There was some minor disagreements about the timing of the use of figurative language, i.e. at what stage in the course they should be used and how frequently. Some agreed that if a long, funny story explained a point well, or served a purpose then timing was irrelevant, some preferred spontaneity to be apparent even if the timing was appropriate while others were very concerned that they should be used sparingly.

"only to be used right at the end - or halfway through when you're having trouble remembering what's happening .... having trouble conceptually or right at the end when you're having trouble with memory".

"I think its a good idea but it shouldn't be taken too far, you'd get fed up".

"if you have too many then you won't remember what you're meant to remember"

"they won't be outstanding then - it won't be special"

A related point was made about them having most use in difficult rather than easy topics:-

"I don't see the point of putting it in, its as easy to say (literal explanation)"
"they are better for difficult things".

Of course, what is easy and difficult is very much related to the individual students perception and also that of the teacher. This is nicely illustrated by one teacher's use of the phrase 'isomerism raises its ugly multiple head'. The students in the workshop generally disliked this because to them it implied that "isomerisation" was a difficult topic whereas they found it easy. With less mature students this may unnecessarily worry them or prejudice their view of a topic.

"I can see the multiple head but not the ugly - that makes it sound horrible"

"I can't think of any nice multi-headed creatures - they are all villains"

"yeh, it makes it sound like it should be difficult but it isn't"

"some of the simple things in chemistry are made more difficult by the stories they put in"

There is a possibility that this problem could be avoided if the teacher actually explained the metaphor or analogy and, certainly some students feel that this would be useful if not also necessary.

"he's got to explain how the metaphor goes with what it does, the topic"
"if a teacher does bring in a metaphor or an analogy it's very important for him or her to carry it on really as far as it will go, because if you don't then the pupils will probably carry it on and take it up the wrong way".

The students also made some points about how metaphor and analogy are useful to them. One of the ways is its use as a memory aid. Although students find that they may be to some extent distracting, in general they find that the unusual is memorable and can stimulate discussion.

"sometimes the analogies become so interesting that you remember the story more than that what they are connected to".

"I think you'd remember it more then"

"Its a fun way of talking about it which makes you remember - and then its useful for talking about after the lecture - a discussion".

"the more weird and wonderful you make the analogy the more you will remember it - which really is true".

Another benefit is stressed by students who have difficulty coping with abstract ideas i.e. the provision of some kind of visual image:

"a lot of chemistry is not something you see every day ...."
everything is so small .... you can't really see things - verbalise it".

"I like it, 90% of my learning is done by this sort of thing .... you could imagine something".

This is also linked to ways of understanding or for coping until better understanding comes:

"surely its important to understand it and these things HELP you to understand it".

"the solar system atom, why that always comes back to me - when someone talks about atoms - is because there are some things about atoms that - its easier to picture that way - its one of the areas that I still don't fully understand."

Recognition is also given to the possibility that these figures of speech stimulate interest and attract the attention of the class:

"anything that can wake people up and get their attention is a good teaching technique".

Another point which received general agreement concerns the idea that the teachers themselves should be 'convinced' by the metaphor. This also has links with the points made earlier about context, timing and explanation of metaphors and analogies,
"another thing that teachers sometimes do is .... they don't feel comfortable slipping them in - so they just throw it in quickly and then you spend the next 4 or 5 minutes wondering what the hell has that got to do with the topic and by that time they've already said something important that you've missed"

From the students reminiscences about examples of such occasions, it would seem probable that they have picked up non-verbal cues, from the teacher, involved in the delivery of figurative language explanations. It would seem logical that if these cues indicate dissatisfaction with the explanation from the teachers viewpoint then the students, too, will have negative feelings about it, finding it at best a waste of time and at worst a distraction causing confusion.

Finally it was also noteworthy that the students all commented directly or indirectly, on the amount of "self" revealed by Mr. A when he used figurative language i.e. he derived metaphors, analogies and descriptive anecdotes from his personal experience, revealing also his preferences and interests. The students views on this ranged from delight at getting to know him as a "real person" to a kind of amused tolerance. However, no matter where each individual student's views fell on this continuum, together they revealed a concensus of opinion that this style made them feel that Mr. A was approachable and was trying to help them.
They produced several examples of amusing mnemonics which Mr. A had introduced and some discussion revolved around how figurative language and mnemonics have properties in common i.e. they summarise ideas; are an aid to memory; are often humorous and are better the more unusual they are.
5.4 CO-ORDINATION OF INTERPRETATIONS FROM CASE STUDY 1

The teacher's view of himself as a teacher and of the methods he uses appears to be consistent across the grid elicitations and negotiations and interviews. In each there is an emphasis on: a personal, empathic approach; interest focussed on teaching the students rather than the subject; careful consideration given to communication and to the provision of variety in presentation; concern for generating understanding as a vital part of exam-passing techniques i.e. he feels his duty is to provide the basic facts while at the same time acting as a learning facilitator for more cognitively complex activities. In chapter 13 of Rogers (1980) "A Way of Being" (pp 292 - 310) traditional and person-centred teaching are described in detail. Mr. A's style would seem to incorporate some aspects of each. Perhaps his training emphasises the traditional side while his natural inclination tends towards the person-centred approach.

This would accord with my own observations made in the classroom of: the prevalence of an informal atmosphere; the high level of interaction between the teacher and students; the care taken to provide formal summaries of topics in the technical language of science after informal, more personalised discussion; wide variety of presentation techniques, including frequent repetition of ideas and explanations in different forms; the provision of individual help to students during or following a lesson; concern for highlighting important points for the exams and for providing aides-memoir.
This evaluation is further supported by the description provided by the students of the teachers style and the conduct of lessons. A recurrent theme in the student interviews was that they were aware of, and appreciated, the friendly, cooperative atmosphere in Mr. A's lessons. The general feeling was that this aided their learning and/or built their own confidence up, sometimes encouraging self-directed learning. From those interviews and the workshop it seems that, in general, the teacher achieves his stated aims of indicating his approachability to the students while, at the same time, encouraging them to "think for themselves".

To turn to this teacher's use of figurative language, it was noted in the lesson observations and by the students that this teacher makes frequent use of this in explanations. Similarly, I noted that, while explaining his role and methods to me in interviews and grid negotiations, he again often resorted to metaphor or analogy to convey an idea - for instance he referred to his "Toy-town explanations" and compared the situation of students in oral exams to our interview situation.

Another pertinent aspect, in addition to frequency, is the nature of the figurative language used. During analysis of the data, a list was compiled of all the examples of figurative language used by the teacher in observed lessons. These fall into several classes i.e.
(a) those which are now traditional in chemistry;
   (i.e. "dead" metaphors, for example) such as "electrons
   orbiting the nucleus",
   "a species of ion";
(b) those involving vernacular language, non-traditional in
science for example:—
   "if we nail those, fix them at known values"
   "you can't magic sulphate ions out of thin air",
   "make the electrons do a bit of work for their pleasure";
(c) those involving "imaginary" experiments e.g.
   "imagine we have got a hypodermic full of electrons and we
   inject them into the system at equilibrium",
   "if you wind the resistance up to infinity i.e. you can get
   a chopper and break the circuit";
(d) those involving personal anecdotes e.g.
   - in a discussion of the relationship of surface area to
   volume, he related an incident when he realised that the
   dimensions of the fish in fish fingers had changed resulting
   in an increased proportion of batter to fish, and — while
   discussion the strain on multiple carbon bonds he told of
   his childhood "bow and arrow" play bending branches to
   facilitate cutting them with his rusty pen-knife.

During the course of this research, the concentration was on the
last three classes, mainly because those in class (a) may cause
some dispute as to whether they could now be classified as such
and because they are so traditional that they are difficult to spot, especially for a fellow chemist.

The integration of classes (b), (c), and (d) as part of Mr. A's style can be seen from the sample lesson chosen for analysis. (Appendix IIb). In this, (class (b)) figurative language is a feature of informal discussion of ideas, while in that one lesson he discussed three "imaginary experiments", (class (c)) and related two personal anecdote-based explanations (class (d)).

I would propose that this kind of use of figurative language is related to his own perceived aims and the reactions of his students in the following ways.
Firstly, the class (b) language may facilitate interaction with the students since they may feel more free to express their ideas when not constrained by example to use formal technical language.

Secondly, the class (c) language may enable students who have difficulty with the abstract to visualise the ideas expressed in chemistry.

Thirdly the self-disclosure involved in class (d) language may help, with other techniques, in building rapport with the students.
In addition all three combine to contribute to the informal atmosphere of the lesson whilst still directing attention to the job in hand— the teaching and learning of chemistry.

In his interviews, the teacher recognises that he uses metaphors, analogies and anecdotes as pedagogic tools:

"they seem to help learning — and if they don't then — at least they are distractors"

and that different students use them differently — those who had difficulty with a concept using them for understanding while those who already understood enjoying them as a "bit of fun" or "for keeping them awake".

Finally, there is a strong emphasis both in the teacher interviews and during his class teaching on helpful aids to memory. Since the students, in interviews, frequently spoke of figurative language in terms of memory aid and since they linked it to mnemonics readily in the workshop, it may well be that this is an example of the teacher tacitly guiding the way his figurative language is used and/or students detecting a subconscious intention of the teacher. Students seldom learn only those things presented on the syllabus.
Overall, from the data, this teacher makes very frequent use of figurative language in his teaching of chemistry and it seems to be a successful strategy in that it serves many purposes related to education, more for some students than others. However, this success may derive in considerable part of his careful thought over matters of communication and presentation combined with the refinement of his teaching technique over his years of experience in teaching this subject. Success may also be dependent on a natural facility in the use of this language form since this study also highlighted some possible caveats about its use.
CHAPTER 6
CASE STUDY 2
CHAPTER 6. CASE STUDY 2.

6.1.1. GENERAL BACKGROUND

The school in which this study was conducted was the same as that in which Case Study 1 took place (See chapter 6.1.1.) Although the research as a whole encompassed schools which each had a very different general ethos, this particular school was chosen for the second case study to highlight a different teaching style, particularly in the use of figurative language, against a common background.

Thus, the timetabling arrangements for this class were similar to that of the previous study but it was a first year A level class, comprising 11 students ranging in age from 16 to 18 years with one older male student (23 years). There were 3 girls in the class. Again the students had the basic minimum of five 'O'levels with a few of the older students having had a break from full-time education.

6.1.2. TEMPORAL SEQUENCE OF STUDY

The order of the fieldwork components followed that as described in section 4.1., the timing of components being the same as that for the first case study but commencing in the second term. This gave the students time to settle into the college and become familiar with its routine and ethos while they were still being
presented with new ideas and topics in chemistry.

Actual audio-recording of lessons again began in the fourth of the observed lessons (8 in total) to allow the teacher and students to become familiar with the presence of myself and the equipment and so to behave more naturally. The actual lesson used as an examplar and for analysis of teaching style was the sixth lesson in the series, being chosen at random from five which seemed similar in format and style.

6.1.3. LOCATION OF FIELDWORK COMPONENTS

The classroom observations took place in a classroom which had the students desks arranged in four continuous rows facing a large teacher's table which was in front of a blackboard. The table had on it an O.H. Projector and several items of demonstration equipment in addition to the teachers notes, and was placed in the centre front of the class, allowing a fair amount of space for the teacher to move about at the front.

The rooms used for interviews with the teacher and students and for the student workshops were the same as those used in the first study (Chapter 5.1.3.)

6.1.4. PARTICIPANTS

The teacher, Mr. B, had spent the 16 years (approx) since
obtaining his degree in teaching chemistry in various schools, having come to this particular school some four or five years ago. At that time he too studied part-time and gained a teachers certificate. As with Mr. A, his dress was generally informal but smart, occasionally topped by a white lab-coat when demonstrating chemical reactions.

The number of students who took part in the interviews was four, again the proportion of males to females being approximately that of the class as a whole. Similarly, the interview sample spanned the range of age, previous chemical education experience and perceived ability by the teachers assessment of the class. This held also for the workshop participants, although two females took the place of two males from the interviews who had timetable difficulties later in the year.

6.1.5. FIELDWORK EXPERIENCES WHICH AFFECT ANALYSIS OF DATA

The methodological points and caveats described in Chapter 5.1.5. are also relevant to this case study, in particular that particular quotations used to illustrate interpretations were chosen with the whole context of the research interaction in mind.

Again the transcripts of the negotiation of grids provided much data valuable in illustrating or extending ideas from the interviews. In addition, this teacher also produced quite extensive grids, showing great interest in the techniques and their analysis, and in the course of doing so revealed that he
had a great interest in computers and computing which took up
most of his spare time. This provided additional insight which
helped with the formulation of questions in the final interview.

6.2.1. DATA AND INTERPRETATION OF CLASSROOM OBSERVATIONS

During the period of general observation of Mr. B's 'A' level
lessons it was noted that the class and teacher appeared to have
established a working relationship which was relatively stable
throughout the eight consecutive visits for full-length lessons
that I made. The general impression gained was that:

- the teacher did most of the talking;
- he frequently repeated items;
- he interspersed his talk with frequent demonstrations
  and models and often made jokes or gave the students
  a few minutes to relax and chat.

Although the students only occasionally asked questions, they
seemed relaxed, ready to laugh at jokes etc. and generally gave
the impression of being at ease with the situation. They did
attempt answers to questions even if only tentatively and there
was no sign of disruptive behaviour and little, if any,
indication of disinterest.

The lesson, which was transcribed and analysed in detail (See
fig. 8, Appendix IIIc) revealed the following points:
(a) The teacher frequently repeated new information given by putting it another way informally and then following this with a formal exposition by way of dictated notes and blackboard summaries;

(b) During the presentation of new information there was frequent linking back from the new material to old chemical knowledge or general knowledge. This was often done by questioning the students - approximately three quarters of his questions to the class were used this way to revise old knowledge as it was related to the new area under discussion.

(c) The remaining questions were of the type in which the teacher would give some information as an example of a new rule and then ask the students to work out the next example.

(d) The students asked 5 questions throughout the lesson; one of these was concerned with administration which the teacher answered directly, another question was answered by referring the student back to earlier knowledge while the remaining three, which concerned areas peripheral to the main topic, were not directly answered, the student being told that the answers would come up in later work;
(e) Having provided new information, the teacher frequently referred to the practical uses or everyday occurrences of the phenomena or to the use that other science areas put the theory being explained.

(f) Of the nine metaphors/similes/analogies used in the lesson 4 were related during the demonstration of models and 2 when giving new information - all of these six were of the personification variety and were relatively trivial e.g.

"if its a bit on the greedy side x can get both electrons".
"neither of these 2 bits floating around is very happy because carbon likes to form four bonds"

Of the remaining 3, one was used as part of a joke, one was a practical application and one was used as part of revision of old knowledge. Each was of the form that described microscopic arrangement or action in terms of macroscopic, easily visualised, entities; e.g.

"it it was a globe and had things round the middle you would call these things - on the equator - equatorial hydrogen atoms"

(g) Solid models of different kinds were used for demonstrations throughout the lesson, being used to show both shape and action of molecules. The teacher frequently made jokes about models e.g. forming them into funny shapes (like a dog) or making the model very large so that he had to "juggle" or "clown" with it.
At one point, while introducing a new model, he told the students how much he "likes playing with models".

From the observers viewpoint, the teacher seemed to dominate the main classroom activity, which appeared to be the transmission of information. He used frequent repetition and amusement to aid this transmission and used questions to check that the information had been correctly received.

There was no lesson plan apparent, i.e. the teacher did not appear to consult any lesson notes, but models, photocopied handouts, and OHP slides relevant to the lesson topic had been brought into the classroom prior to the lesson.

Models were used extensively throughout the lesson and in many cases they seemed to serve the following functions, which are sometimes attributed to figurative language i.e.

(a) to represent abstract ideas or sub-microscopic entities, in a form more easily visualised;

(b) to make concepts and ideas more memorable;

(c) to link new ideas to old, i.e. well-learnt, ones, to the practical uses to which chemicals and chemical concepts were put and to everyday occurrences of chemical phenomena.

This last one gave the impression that the practical utility of
chemistry was important to the teacher or that he felt it would be useful for the students to recognise this.

It was also observed that the students in this class seemed to know and be happy with, their roles as "observers of a performance" and "receivers of knowledge" in that they seldom interrupted the lesson, other than to show appreciation of a joke, but nevertheless apparently paid good attention to the exposition. They also seemed familiar with the form of informal breaks in the lesson which the teacher gave periodically and filled them by quietly chatting amongst themselves or by reading a book. They behaved similarly during the few times in the course of the study when the teacher was called out of the classroom for a few minutes.

Two samples from the lesson are included as Appendices IIIa and IIIb, the first being an example of the initial analysis while both act as exemplars of the teachers style.

6.2.2. ANALYSIS AND INTERPRETATION OF GRIDS

Grid I (See Fig 5 overleaf) contains eight elements which make up the main things that teacher Mr. B. feels are part of his job.

It is interesting to note that one element (5) combines the development of interest and enjoyment in science, with the
CASE STUDY 2 FIGURE 5
GRID 1 - 'ROLE AS TEACHER' - Mr. B.
presumed assumption that the one produces the other.

Two main clusters, quite separate from each other, become apparent on analysis of the elements. These might be labelled the academic components i.e.

(1) passing on information;
(2) developing concepts;
(3) helping to acquire practical skills,
and the more general cultural components.

This second cluster is itself divided into two clusters, one being concerned with the linking of school science to the outside world -

(4)&(7) to develop scientific awareness of the world and to point out the importance of science,

and the other concerned with general pedagogic duties -

(5) developing interest and enjoyment in science
(6) helping the students communicate
(8) motivating them.

Thus, the elements are divided such that five are mainly concerned with the subject matter and three with the students.
The construct ratings indicate that he feels that he spends more time on (2), gains most personal satisfaction from (7) and feels he is most effective in doing (6), the elements which are central to the passing of exams, with the converse also being indicated. It is interesting also to note that those elements which rate highly on "teacher dominant activity" (3) i.e. passing on information, developing concepts, developing an interest in science and motivating the students also receive a high rating on "get greatest personal satisfaction from" (7). "Pointing out the importance of science" seems to be variable both with the topic taught and students taught, and while all of the elements in the general personal/cultural cluster show variation depending on students, the academic elements seem to show a high degree of constancy across all students.

Most of these points are amplified in the transcript of his discussion while compiling the grid. For instance, concerning the link between interest and enjoyment, at one point he says:

"I suppose I naively have the idea that they already have an interest in science - I suppose that I hope that through learning about it they would develop an interest AND enjoy it".

The separation of the two main clusters might be explained by his viewpoint:

"Development of concepts is a fundamental process, whereas developing awareness, enjoyment, interest are more in the line of spin-off".

176
"If you have got a group of students who are reasonably well motivated etc. then you, as a teacher, don't have to actually put yourself out to do so".

"I suppose you know that one of the things teachers OUGHT to be doing is motivating the students, didn't he ...... talking about things ...... that I don't do ...... but OUGHT to"

His attitude towards exams seems to be that they are of central importance and is illuminated by:

"I DO regard it as a very important part of the role to get them to pass exams ...... as most exams test more "facts and principles" than anything else, then that has to go as No. 1. - you could probably just get by in any exam without necessarily developing any concepts etc. - though that's probably a jaundiced view of life".

While sorting cards about what gives him most satisfaction, he makes a point which also links in with teacher-dominant activity:

"if I feel I've given a good class and they respond to it - I suppose that what gives a feeling of satisfaction - if I've just done a barn-storming lecture on something".

Similarly, he later adds:

"I suppose basically I am a performer ...... I suppose the performing arts bit comes out when I do demonstrations - I don't mind hamming up a demonstration".

The final point about constancy of the academic elements is expanded in:

"Facts and principles - I don't think that depends on the students all that much because I think you are pushing facts all the time - it's a constant activity, regardless of what students you have".

From the Second Grid "Methods Used in Teaching" (See Fig 6 overleaf)

the clustering of the ten elements produces some interesting suggestions e.g.

(a) "normal lecture" (1) and "solid models" (5) are closely linked and he says about models:

"you could build models of practically anything" indicating that they form a very integral part of his teaching.
### METHODS USED TO PUT ACROSS IDEAS

**Mr. B.**

1. Use often with activ. sts - Use less often
2. Use less often - Often with less activ. sts
3. Central for giving ideas - Peripheral
4. Easy to incorporate - More difficult
5. Like doing most - Like doing least
6. Dependent on topic - Less dependent on topic

---

#### CONSTRUCTS

<table>
<thead>
<tr>
<th>Construct</th>
<th>Elements</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>6. Anecdotes</td>
</tr>
<tr>
<td>2</td>
<td>5. Analogy &amp; metaphors</td>
</tr>
<tr>
<td>3</td>
<td>4. Maths proofs from laws</td>
</tr>
<tr>
<td>4</td>
<td>3. Ref. to everyday exper.</td>
</tr>
<tr>
<td>5</td>
<td>2. Student experiments</td>
</tr>
<tr>
<td>6</td>
<td>1. Experimental ideas</td>
</tr>
<tr>
<td>7</td>
<td>Solid models</td>
</tr>
<tr>
<td>8</td>
<td>Normal lecture</td>
</tr>
<tr>
<td>9</td>
<td>Question &amp; answer session</td>
</tr>
<tr>
<td>10</td>
<td>Individual help</td>
</tr>
</tbody>
</table>

---

**METHODS USED TO PUT ACROSS IDEAS**
This is echoed by their rating on constructs "central to putting across ideas" (3), "2nd nature (easy) to incorporate" (4) and "like doing most" (5).

(b) The 89% of linking of "reference to everyday experience" (2) and "metaphors and analogies" (4), may indicate that the one helps to define the other. These are closely linked in a group with demonstrations (7), student practicals (8) and maths proofs (10). The link between these may be explained by:

"I don't think I accept that there is anything which is that theoretical that you can't in some way visualise it by diagrams or visual demonstrations. You can't always directly demonstrate some things but you can make pictorial presentations of it".

(c) These two main clusters are linked to each other but the second one seems to be more of a supportive nature to the first:
"Analogies and so on are used to relate concepts TO something - they're used to support ideas".

(d) Element (3) "Anecdotes" is linked to the two main clusters but is somewhat out on its own. Although he finds them fairly easy to incorporate and doesn't mind 'doing' them, he uses them most with more motivated students and least with less motivated students. Apparently he does not see them as a way of motivating students so that, since he also sees them as peripheral to putting across ideas, they are used more as a break in the lesson for the hard working rather than as an aid to the struggling student or as a form of explanation.

(e) Very separate from the other elements come (9) "Individual help" and (6) "question and answer sessions". Two points of interest here, firstly that he is, from the constructs, very unhappy with the time spent on these and from the discussion he remarked that these were two things that he felt guilty about not doing more of:
"Obviously its something I've got to work on more".

The second point is that he uses question and answer sessions most with the unmotivated students - this he explains:

"is harder work but its a way to get them involved and interested"

This suggests that, to him, these sessions involve his asking the questions and the students answering. This is supported by a comment made later that he tends to use question and answer sessions more in the way of "class control" than for other purposes i.e. as a punitive device for non-motivated classes.

An echo of Grid 1 is found here in that the constructs "like doing most" (5) and "are second nature to incorporate" (4) are linked with construct (3) - "are central to putting across ideas."

A further link with the first grid - his preference for teacher-dominant activities - comes with two asides made while compiling this grid:

"I find student practical work a bit of a drag really - I don't get a lot of satisfaction from it - they are DOING it."

"I don't tend to consciously ask myself what the students prefer or like".

In the first grid negotiation he made a point about an element which superficially looks like encouragement of active participation on the students part:
"if I am helping the students to communicate logically then again I am in the role of TELLING THEM WHAT TO DO" (Teachers own emphasis).

Similarly, in the second grid, although he recognises the value of students participating in practical work to gain experience, the accent is still on teacher-direction:

"one of the reasons for doing practical work is to teach the practical skills but the other reason is to actually give them some first hand experience of the theoretical stuff in practice".

This point is emphasized further when he later spoke about how he eventually turned a practical into a demonstration lesson because the students, apparently, were not doing it the "proper" way:

"I started off doing that as a class practical and that was a total disaster, their results went haywire - they just couldn't do it - in the end I decided I would do it as a demonstration - I've used it for a number of years - I could do it with my eyes closed and guarantee that the results will come out a perfect straight line, so I ham it up a bit".
6.2.3. DATA AND INTERPRETATION FROM INTERVIEWS

(a) Views on Teaching and Learning

During the course of the interview, Mr. B. stressed to the interviewer that he saw the main part of his job as being the transmission of information and understanding, the two being integrated and important for the passing of exams:

"I come and I do a job and that is to get them to understand chemistry and pass their exams and proceed as they wish to"

"talking about it and explaining it and hopefully you've not only got into their minds what they've got down on paper but the background as well and understanding of it"

"The effect you should be having is to get the students to understand certain concepts and to get across the subject - with the least possible fuss in the minimum possible time"

Throughout the interviews, he generated a picture of the teachers role being the active one while the students role is more passive, although he does have certain expectations of the students as receivers or perceivers of the teachers activity. This will become more apparent as some of his other main concerns and ideas are illustrated.

He seems to have clear cut ideas about what and how chemistry should be taught, or at least how it should not be taught:
"...... there's a body of knowledge that a chemist ought to know and therefore to give students an option ...... seems to me an abdication of responsibility ...... I cannot personally understand these people who say that an examination system set from as set-down syllabus is a bad thing, because in a subject like chemistry I think its essential that there are certain core things that you know about ...... its vital that if anybody claims to know anything about chemistry ...... perhaps I must reveal my colours in as much as perhaps I am teaching those who wish to go on and use chemistry further ...... so perhaps I sort of to some extent ignore the possibility that some of the students will not wish to pursue chemistry any further".

"most of the concepts in chemistry, there's no way a student is going to be able to discover in any meaningful sense - those concepts by fiddling around in the laboratory ...... I'm a reactionary being - basically at heart ...... I think its (old fashioned teaching method) the most effective way of getting across topics like chemistry or physics, full stop".

Although he seems to favour having a clear, set syllabus provided, he personally prefers to choose for himself the order of presentation i.e. he feels the syllabus should be flexible but not too greatly so since there are some teachers in whom he would not place much confidence:

"although I might of originally taught almost identical material overall the fact that the (Tech) syllabus was organised in that way would throw me ...... now I just forget about it and just do the topic in my own way ...... and just check to make sure that there are no points that I've missed out - the A level courses - you have that much more flexibility because there is no implied sequence".

"I want to have SOME leeway - I don't want too much but I like a little bit ...... I think its more reasonable in as much as I think there should be national standards ...... therefore I think it is dangerous if you give too much leeway ...... there are some people who don't seem to know their subject very well ...... I'd hate to give them a lot of leeway".

These ideas seem to coincide with his declared 'spontaneous' method of teaching which at the same time allows him to cope with differences between students to some extent:
"I do like to make my teaching spontaneous up to an extent"
"I don't have a lesson plan - I just take it as it comes"
"I suppose that varies from group to group - some can take more discourse than others - but only marginally, I don't think I change that much".
"It worries me if they find it difficult but I don't mind actually explaining it - if you have to do something about maths so that they understand the chemistry you give them, then you have to do it".

Mr. B. gives the impression that he finds the subject exciting, especially its practical relationship to the real world and its theoretical patterns, and also expresses the view that this enthusiasm for the subject taught is an important facet of good teaching:

"I find some fascination in the ideas we were talking about this morning - hydrogen and oxygen reacting together and the fact that that's what shoots the shuttle into space ...... I find chemistry satisfying, in as much as it does have these practical uses and also internally satisfying in as much as you CAN find things which form nice patterns".

"If the teacher is enthusiastic about what he is teaching then it DOES come over to the class and its far more likely to keep them awake and interested ...... so it's part of a necessary attribute for a person who hopes to be a good teacher, i.e. that they are interested in what they are trying to put across".

While discussing his own enthusiasm for chemistry, he said:

"I suggested that one of the reasons you might study organic chemistry was because you're interested in it ...... with some classes that's actually received a guffaw - I must admit - I thought - Oh hell - I don't know - depressed".

This disappointment with low or disinterested feedback from students and a preference for already motivated students is reiterated throughout the interviews, especially in that he acknowledges an interdependence between the students reaction and his teaching style:
"if you've got a dozy group in front of you who is not responsive at all - it just makes me feel switched off - you just dread walking into the room because you know you're not going to enjoy it".
"if you have got a system with a sort of linear subject - I think you have got to cream, other wise it's a shambles".

"therefore it does increase my enjoyment if I'm finding ...... that I am actually getting through to them".

In earlier interviews there seemed to be an implicit assumption that the students should "arrive" motivated and I queried this in the final interview. His reply was:

"there's no point in an audience going to a play if they are not interested in what the play's about ...... in the same way the actor gets a kick out of the audience responding well to it, well so do I".

This analogy was used shortly after I had checked with him another impression I had received earlier, that he frequently depicted himself as giving a performance to an audience, somewhat like an improvisation actor. This, he thought, aptly described him. A selection of quotations illustrates this.

"you go on sort of an ego trip when you're in front of a class".
"I enjoy trying to put it over well"
"its more pleasant to be able to demonstrate things"
"I like that demo - I suppose I like to ham it up a bit"

Although he says that he finds mathematical proofs pleasing himself, he does try to accommodate some of the students, those he sees as not having mathematical minds:

"if they're not mathematically minded then there's very little to be gained in trying to produce an argument which would appeal to somebody with a mathematical mind".
He also expresses the view that repetition and amusement are aids to learning:

"I think you probably tend to remember things that are amusing, yes, I think it does help them to learn".

"so maybe that's why I do it, I have been told that repetition is a good thing in learning".

While sometimes critical of his own teaching:

"I don't set students a vast amount of descriptive homework which is a failing I periodically think about - but rarely do anything about I regret to say - I tend to stick more to calculation"

"I'm perhaps not so responsive to my classes in some respects as some people are".

In the main he gives the impression of enjoying teaching although it is hard work:

"it can be an enjoyable activity even if it is tiring".
"if I enjoy teaching in as much as if I am teaching something I am confident about and interested in then I generate a certain amount of enthusiasm for that"

"if you are conscientious its quite a demanding job - I certainly haven't found it an easy life".

He also transposes the idea of hard work generating enjoyment, a kind of puritan work ethic, to his students:

"I hope they get some enjoyment from it - I can't really conceive of a situation though where they didn't get anything out of it but they all worked hard".
As in Case Study 1, quotations from Mr. B, concerning teaching and learning were categorised as per the scheme in Fox's "Personal Theories of Teaching". Most fell into the "transfer" theory category. Both the "travelling" and "growing" theories were unrepresented. This provides further support for the interpretations derived from the preceding data. See Fig. 7 (overleaf).
Communication and Rapport with Students

As was indicated in his view about teaching, he seems to gain enjoyment from the production of a good explanation especially when he receives positive feedback in the form of intelligent questions and answers from his students.

"if I've got students who are actually coming back either with ready answers to my questions or asking intelligent questions which show they have understood what I've said - then that I quite enjoy"

He suggests that although these "good explanations" may initially occur spontaneously, they may be developed and refined with practice and repetition:

"I suppose I must use the same ones again and again ...... probably developed over the years"

Scientific explanations are seen as both interesting to him and, he feels, are made more interesting to the students if they are linked to examples of practical use:

"they have relevance because we can apply them into the real world - you know thats what I find fascinating about knowledge ...... and I suppose I like thinking the students do enjoy it if you point out the fact that (gives an example) - facts like that are of interest and perhaps make it a more REAL subject to them".

Language, from his viewpoint, is not seen as a great problem but he has been surprised sometimes by the lack of student familiarity with some words and so he expresses the view that if they had a richer vocabulary then it would ease his communication with them:
"unlike a school situation the majority of the students here are 'mature students' therefore in terms of their language development in a general sense you expect them to be more adult ...... obviously you have got to modify your technical language to take account of its O or A level but otherwise, no, ...... Having said that I was appalled when I asked them about terms - words they might have heard and they just hadn't - it was obviously not in their experience ...... I don't know whether I was expecting too much in terms of education ...... as far as I am aware language isn't a great difficulty - but I don't know - I don't thing of checking back to make sure - obviously the richer their vocabulary is in a general sense the easier it is to communicate"

There were several occasions when he mentioned the importance of previous experience, both at home and in school, for understanding science. For example, he discussed the possible home experiences of boys and girls which might influence their reception of science even though there are no other fundamental differences, in his opinion, in the way they might think:

"it stands to reason that the boy (in the example) is more likely to succeed in science than the girl simply in terms of experience as a young child - the environment in which the child is brought up"  
"girls coming from an establishment - that hasn't actually got any hard mathematics and physicists - aren't going to like mathematical explanations because it simply is not their past experience and therefore they just wouldn't understand it"

He also related his own attitudes towards biology to his own experience at a boys' school where biology was thought to be a "girls' subject".

This may be the basis of his concern for elaborating on explanations and providing a variety of versions of explanations, usually as additional to, or reinforcements of, the initial basic explanation. This "embroidery" he feels can be discarded when the basics are understood:
"if you are trying to explain something - that you think may be a new concept to them - then you try and put it over in as many different ways as possible - you can explain it in a very straightforward scientific way - which might leave some of them without following it - then you follow it up with an analogy to something they have experienced ...... it probably reinforces it all"

"The anecdotes side is probably supportive - I don't tend to use the analogy as the initial presentation - I try to reinforce the facts and make it clearer using analogies".

"you embroider on it and explain things away - until they have got the basic idea"

"I like models I must admit, something to do with a childish nature, but I do like to have different types of models to play around with"

"I suppose I do tend to feel that you need a clear PICTURE in your mind to begin with ...... you know I think models help build up a mental image of what's going on, which you can then apply ...... when you are trying to solve ...... problems"

On the occasions when I asked him how the students received a certain kind of explanation, the usual reply was

"I don't really know, I haven't asked them"

however, it is apparent that he does take some notice of how things are received.

"its maybe that I feel sort of ...... blank looks on the faces around - that I try and have another go ...... because they haven't picked it up the first time round".

However, overall in the interviews there was a much greater emphasis on Mr. B's part on how material is, or ought to be, taught than on how it is received.

(c) Views on science in general and chemistry in particular

The general impression given by Mr. B. is that he sees science as intrinsically interesting in its own right - see earlier quote about studying it for its own interest - but there is a very strong emphasis throughout on its practical, utilitarian value:
"One of the things about science is that it does tell you about what goes on"
"one of the things I like about science is that it does enable you to explain what's happening in the world around you - to explain either everyday phenomena or something that you can actually say 'Oh yes, well I can understand WHY that does and so'".

(how he would explain what chemistry is to a lay person)
"I suppose you would do it in terms of what chemists can achieve - in terms of fundamental processes like converting an unpleasant-looking piece of rock into a piece of shiny steel - or North sea oil into plastic".
"I think chemistry - doesn't really have much purpose unless its practically orientated".

Thus, he appears to see science as providing fundamental explanations of the world and further that its future progress lies in generating deeper and deeper explanations and refining ideas, limited only by available technology:

"its like the Russian doll thing - I mean you keep taking off a layer and get something underneath ........ you are always going to discover something different I think ........ as to whether you are ever going to get an end point in the scheme of things ........ you really need to divide science off from the technology there. I don't know whether there will be very much new discovered in chemistry as such ........ in terms of factual new theories ........ obviously things like bonding theories will be refined and made much more mathematical ........ I think it'll mainly be a question of refinement in terms of the pure science angle ........ in terms of the applied science thats another matter - in terms of inventing new materials thats a feasibility ........ I don't know in terms of fundamental theories if there will be any more discoveries".

During the discussion, he recognised a possibility that current theories may be wrong but that this was unlikely he indicated with laughter in a following remark:

"I don't think there is an certainty that a theory is correct (laughs) there would be an awful lot of upset people if some of the fundamental ones proved to be not quite as they should be".
There is also a prevalent idea put forward that the sciences are somewhat separate disciplines with physics, chemistry and maths being more fundamental than biology:

"I don't see the point of attempting to go for interdisciplinary and integrated science - you are just drawing the lines in a different place that doesn't really achieve anything ....... no point in jumbling it up all together".

"if you wanted to put together a set which would enable you to understand the rest, you would need to do physics, chemistry and maths ....... it doesn't strike you that biology has so many fundamental concepts as you have in subjects like physics and chemistry".

"modern biology ....... you can't get far without chemistry".
6.3.1. STUDENT INTERVIEW AND WORKSHOP DATA AND INTERPRETATION

- GENERAL POINTS

(a) Again, to reiterate briefly the point made in 5.3.1.(a), the semi-structured nature of the interviews meant that the question order was dictated by the students' responses, some research questions being answered directly while the answers to others were found in asides or incorporated in other answers.

(b) With this group of students there was a wider variation in degree of relaxation and articulateness during the interviews. The one older student chosen was very relaxed and prepared to expand on ideas. The other three gave shorter answers to questions but seemed willing to give information as long as questions were asked. There was, however, a feeling on my part, supported by a few post-interview comments such as "did I do alright?", that these students were concerned to provide the 'correct' answers to questions although they did not seem too concerned about mode of expression i.e. they tended to use ordinary conversation-type language rather than technical or correctly formulated language.

(c) Each student interview was analysed separately (Section 6.3.2) and then the resulting data was co-ordinated (Section 6.3.3.)
6.3.2. INDIVIDUAL STUDENT RESPONSES

As in Case Study 1, each student, represented by code initials, is briefly described and then his/her views on (A) Science in general, chemistry in particular; (B) General teaching and learning; (C) Mr. B's teaching style and also any experience of use of figurative language, are summarised, each being followed by quotations which represent the views expressed.

STUDENT G.S.

Male - has maths, physics, chemistry O levels - mature student (early 20's) voluntary day release - promotion in job requires A level chemistry and physics.

(A) Views on Science in general, chemistry in particular

The three sciences are separate but blend sometimes; scientists have particular kinds of minds, think in a particular way and do things in a particular way; scientists find things out: chemistry is different because of not being able to "see" things.

"I see them as separate subjects but blending sometimes as opposed to just the one subject with some separation - I think they are separate subjects". 
"(scientists) they know how to well take things apart........ they'v a certain way of just doing things - just analysing things - its the way your mind is ........ just the way you can look at something and try to figure out yourself - we'll have to do that to find out what it means' ........ I think its the way you look at things".

195
"I see them as just plodding on finding things out ...... its the scientists in the first place who can ...... looking at things in certain ways, figuring out tests, experiments etc. ...... looking at all what happens ...... scientists are the people who find out about things".

"chemistry is difficult in some respects, that way ...... when you're talking about atoms and that - 'cos you can't seem 'em".

(B) Views on Teaching and Learning in General

Teachers should take an interest in you ...... encourage you.

Trying to picture things and remember them at the same time is difficult. Understanding is aided by giving something new something to relate to ...... analogies and practicals are interesting and aid attention - mathematical proofs are frightening - different methods of presentation encourage learning.

"If somebody takes an interest in you, you know, just a little kind of thing, I think they'll get more out of me".
"this trying to picture and trying to remember so many different things that are all going on at the same time can be very difficult"

"I think analogies ...... I always try to use analogies because if you put it in terms that a person can relate to ...... personally I believe they'll always see it quicker, than demonstrations or using formula:e ...... it makes all the difference in the world if you can see even a wee test ...... its not just TELLING you something - practical tests - now SEE, I told you - I think that can add to your interest as well ...... Oh I'll pay attention to this guy ...... somebody just proving things with a lot of formulae would put me off"

"If you can put something in terms that people can relate to its not just totally new or totally different from what they've been doing before ...... and relate it to something they can identify with I think ...... I believe people understand it better".

"the likes of the Horizon programme on television, if they just put the script on the programme in the library I don't know many people who'd read it, but they can put it on the television, put different things in different colours ...... everybody watches it because they can understand it
but just reading it, nobody'll bother”.

(C) Views on Mr. B's teaching style and his experience of figurative language

Appreciates ability to ask questions if stuck and interest taken in him ...... uses his models to form pictures but feels models only indicate shape not reason - they have limitations ...... analogies are the kind of things he can relate to ...... can get a picture from ...... everyday terms help ...... uses them to explain things himself, relate to things known.

"I WOULD ASK because he does say 'do you know what I mean, any questions',"
"Is this all right? - that impression comes over in different subjects as well - they do give the impression that if you're stuck 'I'll help you with it ...... thats what I'm doing here'".
"what I'm trying to say is people here seem to take a real interest in you - you know - 'if you can't handle it TELL me'"
"if he's showing us small models I'll look at the model and just picture it from that - rather than in my head".
"I think it helps in the sense that - if you could picture it this is what it would look like - it will help a bit but you don't really LEARN just looking at the model - you can see the shape of it but the model doesn't tell you WHY its that shape really".
"an analogy, that kind of thing, that's the kind of thing I can relate to - technical things - thats rather boring but an analogy - you know, people can get a picture so that's fine - its easier for me"
"I'm a great believer in them, even in the normal course of my life if I want to explain something to somebody myself, I always try to use analogies"
STUDENT D.T.

Male student, has O level sciences, studying A level chemistry, biology, environmental science, to take up a job with the forestry commission.

(A) Views on Science in General, Chemistry in Particular

Chemistry is hard because it is mathematical, theoretical, contains a lot of laws that make it difficult to see "why". However, it does help with the understanding of biology, environmental science and the outside world.

"I think its a harder science than biology and E.S. in that its got a lot more maths - I can't really explain what I mean but its a lot harder to ....... understand".
"it contains a lot more laws and things like that, that you've got to learn" 
"In biology you can relate it to part of your own body while chemistry you can't do this and its a lot of theory - which ....... doesn't really concern you as a person ....... its a lot harder to sort of see why ....... I think".
"its a very good basis ....... helps you to understand biology ....... you can understand how chemical reactions take place within the body which is a lot more helpful really - same with things like photosynthesis and ....... in environmental science you get the same sort of thing." 
"the chemistry at school ....... its very good ....... for outside school as well because you begin to understand things ......... I like going over to the Forestry Commission Research Centre and I can actually understand how things are beginning to work now"

(B) Views on Teaching and Learning in General

Likes to take an active part in lessons - note-taking/lectures are boring; doesn't like rote learning, prefers to understand what's happening; likes variety in lesson with emphasis on active participation.

198
"when it doesn't tax your mind, when they just talk the whole lesson and don't give you any exercises to do ...... cos I don't mind doing them but I find them hard to do ...... its something to keep your brain going while if you're just taking notes all lesson I think it can be a bit ...... thats boring.""(rote learning) I mean you're learning the basic but then you want ...... I think I want to go a bit deeper than that and to actually understand it."
"using different things to describe an atom because you can actually picture it in your mind - what you think it would look like, I think thats quite helpful ...... practicals, doing it by yourself is quite good as well, because ...... you can learn a lot more I think doing it that way".

(C) Views on Mr. B's lessons and his experience of figurative language.

Gets more of an understanding of why things happen; demonstrations and models keep up interest but would like to have more opportunity to use models himself, would give a better image. Likes analogies to give initial picture but would then sort out his own idea.

"In this class because you go down to it in a deeper depth you can actually get more of a feel for it and really understand why, before you took it that it actually did happen but now you can understand why it happens and I think that sort of clears up a lot of misty areas" "(models and quick demonstrations) I think it keeps your interest in the lesson - but I also think what a good idea it would be to er actually have a go at making the models - you can actually see what it looks like instead of having it flat on a bit of paper" (see final quote in previous section) "(analogy) I think I'd start off with that then try to ...... think of my own sort of idea of it somehow"
STUDENT P.H.

Male student, has science O levels, studying biology, geography and chemistry A level because he is interested in joining oil industry.

*Not taped - student took fright at last minute. Evidence has been taken from notes made during and immediately after interview.

(A) Views on Science in General, Chemistry in Particular

Biology and chemistry overlap a lot - makes it easier when topics occur in both; some chemistry is very mathematical which is worrying and tedious; some laws and facts are known but we have to guess or hypothesize about others - ideas may change about these in the future.

"its nice when you do something you already know a little bit about. It helps to make the new thing easier to learn because you feel that you have already got some ideas about it".

"we might get new explanations of things we don't know all about yet but of course some things have been found out ...... the things that we know are the laws and facts but we still - have to guess or make hypotheses about other things and we may change our ideas about them in the future".

(B) Views on Teaching and Learning in General

Likes informal atmosphere, friendly approachable teachers, having demonstrations before practicals to help understanding; dislikes
facts given staccato fashion or mathematical explanations and appreciates a fair amount of 'padding'.

"I like when you can have fun with a teacher, talk about everyday things ...... feel you can make friends with them so that you can got to them with problems".
"I don't like it when they give you the facts one after another, b-bum, b-bum, b-bum."
"sometimes when you're doing an experiment you don't really know what's going on, can't relate it to the theory"

(C) Views on Mr. B's lessons and his experience of figurative language

Enjoys lessons - more informal than school; humour element sustains interest and helps him feel at ease to put forward problems - brief demonstrations now and then help him to remember the lesson but he wouldn't like them too frequently. Likes stories, relations to everyday familiar objects; they help him to remember. Occasionally found it hard to sort out the facts from the stories.
STUDENT M.S.

Female student, has science O levels. Studying Chemistry, Human Biology and Psychology A levels to go on to study nutrition at university - hopes to become a dietician.

(A) Views on Science in General, Chemistry in Particular

Biology and Chemistry are different but they overlap, sometimes a common basic vocabulary which helps memory.

"I think they are different but there are some things that overlap in them ...... which helps me because I can connect it ...... like the meaning of the word lysis - splitting in both chemistry and Human biology helped me to remember that word".

(B) Views on Teaching and Learning in General

Prefers to have teachers notes dictated, to "just learn" material, helps if links can be made, likes practical experimental work, learning from own mistakes, dislikes maths explanations and is confused by different explanations give at O and A level.

"There is something I don't like, its when you have to make notes while teachers are talking - I can't seem to think of what they are saying and write it down at the same time".
"I tend to sort of look at something - and just memorise it".
"If I can link it up with something else ...... thats a great help".
"I like actually doing an experiment myself ...... learn by my mistakes ...... if the teacher does it he knows what he's doing and does it quickly and if you ...... don't understand it you get lost ...... I mean I do".
(C) Views on Mr. B's lessons and her experience of figurative language.

Likes teacher, finds him helpful; finds figurative language very helpful but has difficulty imaging own, solid models help.

"I think the teacher helps a lot ...... I like him"
"I find analogies very helpful because my own pictures don't seem to be right - but I couldn't make them up on my own".

"thats when its nice to have a model - helpful".

203
6.3.3 GENERAL RESULTS OF ANALYSIS OF STUDENT INTERVIEW DATA

A. i) Views on science in general

These four students have less experience of academic science than those of the previous case study. Therefore, it is not surprising that they seem to have formed less clear ideas about science as a field of knowledge, and to have more simplistic notions about it relative to the students in Case Study 1. These conclusions are supported by the evidence from the transcripts that, although each of these students was very articulate on other issues and could discuss abstract ideas, their comments on the nature of science tended to be in concrete or behavioural terms. One idea that they seemed to hold in common was that science is divided into three different disciplines (biology, chemistry and physics), each of which overlaps the others to a greater or lesser extent. Only the oldest student in the group (G.S.) was prepared to discuss at any length what science was concerned with and even his discussion was mainly focussed on what kind of people scientists are and what they do.

ii) Views on chemistry in particular:

Although all four students saw chemistry as having something in common with the other sciences, three of the students expressed a similar idea that it was particularly difficult because of its less concrete nature: one spoke of not being able to see things;
another about its theoretical nature while the third was concerned about the high frequency of hypotheses or 'guesses'. The last two also saw it as very mathematical and containing many laws to be learned.

(B) General Views on teaching and learning

i) Two of the students specifically mentioned what the teacher should be like in the teaching/learning relationship - that s/he should be interested and encouraging or friendly and approachable. The other two students expressed notions similar to each other i.e. that they felt they learnt more when they were more actively involved in lessons.

ii) All four students indicated that they would be unhappy with the mere presentation of facts. They felt that extra material ("padding") or different kinds of presentations and variety in illustration, or the linking of theories to other ideas and subjects, were essential to understanding, remembering and maintaining attention.

(C) Views on Mr. B's Teaching Style

In general, the students spoke of Mr. B's style in terms of what they thought about teaching and learning (see last section), indicating qualities in it that matched with their indicated requirements. To illustrate this, the student who thought that teachers should be friendly and approachable and appreciated
"padding" in presentation also commented that Mr. B. was more informal than previous teachers, that he allowed for questions from students, that the humour in his presentation helped the students interest and his demonstrations helped their memory. All of the students commented on the interesting nature of his lessons although there was one direct comment and one implication that the students concerned would have like personally to work with the models used in demonstrations.

ii) Views on the use of figurative language

When asked about explanations which helped them in their learning, these students spoke about analogies, relating new material to the already known, 'stories' which relate the new to the familiar and the use of 'everyday language'. They were less forthcoming than the students in the previous study about how these things were helpful although one student spoke about being better able to picture things in his mind while another thought that analogies were useful in giving initial ideas about a topic. Another thought that the presented analogies were helpful but could not envisage creating her own.

Two of the students mentioned solid models in this context. One of them felt that models and analogies served similar helpful functions in that they could help provide an image of structure but that analogies were less limited than models in 'explaining why' or function.
One student noted that sometimes he was inclined to confuse 'the facts and the stories'.

Again a check was made comparing students' views on science and views on teaching and learning with their views on figurative language use. No specific within-student pattern emerged but a general impression across all four students was gained of the following sequence of ideas:

Chemistry is difficult and complex and therefore needs careful presentation, particularly linking the new to the familiar. Analogies are useful in this context, as are models.

6.3.4. STUDENT WORKSHOP DATA AND INTERPRETATION

The samples of figurative language used for discussion in this workshop were the same ones as used in Case Study 1. Samples of these along with notes made on them by two of the students can be found in Appendix IIIId.

Only two of the samples came from lessons in which these students took part. In neither case did any of the students note this and they had some suggestions for their not remembering them when it was pointed out to them after the second instance. These will be noted during the course of the description of what occurred during the workshop later in this section (p. 6-48).

The kinds of benefits acknowledged for figurative language during the discussion included:
their use for engendering pictorial images;
their use as memory aids – especially relating them to everyday objects or occurrences;
their aid in understanding;
their use in making chemistry lessons easier to listen to and more interesting.

As with Case Study 1, these seemed to be mentioned with almost equal frequency, again with acknowledgement of the difficulty in categorising particular comments into each category as noted in section 5.3.4. The only notable difference here is that one particular student 'R', male, always emphasized usefulness for understanding as being relative only to getting 'the basic idea' or in the initial stages of learning a subject.

This idea first came up at the beginning of the workshop when the first phrase, "atoms are spheres", was being discussed.

"Alright for basics – it sort of gives you some idea of what it is"

The other members of the group agreed with another student who felt it was particularly useful in extending the usual mode of presentation:

"I like it because it gives a 3D impression rather than lecturers always using a blackboard – it shows it IS a sphere not something just two dimensional".

The second sample phrase "the nucleus is where the pips would be in an apple" was also felt to be a useful initial description but
but some discussion then ensued about the limitations of such models if no background knowledge was available and the model were taken too literally.

"if you are starting from basics and you have no idea what it is you might think there is more than one nucleus or there might be a little skin holding them together"

As the next sample was discussed, two of the students continued to express the idea that such things were useful when one was new to a subject area, while the other two students pushed the proposed models to their limits, pointing out how they could lead to misunderstanding in such circumstances. This disagreement continued with the discussion of 'electrons live in shells' when different interpretation of the word 'shells' (sea-shells or onion rings) could lead to either misunderstanding or better understanding.

The usefulness of the phrase 'electron cloud' again brought in the proposal that it helped elicit a 3-D image but one student found it confusing because she felt it was still too abstract an idea:

"I think its all too abstract - its all - nebulous - any old shape going anywhere - you can't draw diagrams of a perfect little thing"

For the next two samples, in each case one student found them difficult to relate to what had been previously learnt, two thought they were quite good and one was readily reminded of the diagram shown in that topic lesson.
For the sample "imagine standing on the nucleus looking out at the electrons" there was again reiteration of its usefulness, particularly for 'younger' students:

"(Useful) when you are smaller cos you are trying to relate it to what you see everyday".

All the students correctly identified the source of

"you've got to do a lot of hard work to take off 4 electrons"

and generally liked it as an explanation. One student particularly liked the idea of personal involvement:

"it gives you more idea about what's going on if you've got to do something".

Student 'R' expressed the idea that more formal wording such as "more energy input" would be more appropriate but the others disagreed.

"I think if it's a particularly difficult topic it's better to take it back to more basic - rather than using technical words - you just get more confused - but if it's in plain simple English you've got more of a chance of understanding it".

The students had difficulty with the next sample, seeing no point in it - see discussion on relevance of context to explanatory metaphor in 5.3.4.

The students present who had studied biology liked the implications of 'different species of ion' and discussed its meaning in relation to their ideas from biology but those without
this background thought that 'species' was just a term used "if you don't know the correct group or name" which illustrates the importance of using figurative language which relates to the experience of the students.

The discussion then became more generalised around the area of usefulness of figurative language and talking in a personal way in lessons eg.

S1 "It's much better to do it like that than just plain chemistry - it makes it more interesting and easier to listen to - what one of our chemistry teachers does is to relate it to everyday things and the other one doesn't and you find that when he doesn't relate it you sort of lose interest".

S2 "(metaphors good) - especially if you use them for something that is difficult to remember cos you remember it because of the metaphor - but to use them too many times - then you could get mixed up between the metaphors - it could confuse something you understood".

S3 "It's good as long as they are careful about what they tell you as you can easily get the wrong impression - but if they are thought out well - it makes it a lot more interesting".

S4 "If you can relate it (chem) to something you are familiar with everyday then it helps you to understand it".

It seems that several important points were being made in this discussion. These were that figurative language makes the lesson interesting and helps memory and understanding but that if it is not well thought out and/or presented too frequently then it could cause confusion.
There were quite a few giggles and laughter while the second sheet was being filled in. The students said at the beginning of their discussion of it that they had found some of the samples amusing.

Three of the students like the use of 'skeletons of molecules' and could link the idea to models they had seen. However, student 'R' felt that more precise wording would be better since he thought that skeletons "are not a fixed shape really" although he amended his first statement slightly by suggesting that it might be useful to put over the idea of 'strength' for those who knew this property of skeletons.

Similarly, he felt that the sample "tug of war between two nuclei" was "too waffly" but he was noisily shouted down by the other three students who were enthusiastic about the image conjured up by the phrase:

"conjures up a nice picture - I can really imagine that"

One of the three then explained the metaphor:

"there's tension in the rope which is the attraction and the pull on either end is the repulsion."

The next three samples generated a discussion in which the students again stressed the importance of background knowledge i.e. familiarity with the vehicle of the metaphor or the base of the analogy, and also that these should be of interest to the students eg.
"you've got to know something about gardening or biology to understand the analogy for the chemistry"

and

"most children think politics is boring, so as soon as you start bringing politics into chemistry, then they are going to switch off"

The next sample - 'a never-ending cyclic process - a hole in my bucket situation' was one of the sample derived from one of their earlier lessons although none of them could recall its use. They discussed this and seemed to come to a consensus that analogies etc. are only remembered if difficulty was experienced with the concept. One student summed up the discussion:

"if you tend to understand it anyway you don't tend either to listen (to a further explanation) or remember the analogy".

As the discussion continued to the next samples, two main points were made. Firstly, most of the comments again indicated that the ideas in the samples were good reminders of graphs and diagrams seen in lessons. Secondly the idea was reiterated that if a concept was used from one academic subject to illustrate an idea in another then it was useful for strengthening understanding in both subjects.

The 'ugly multiple head' description of isomerism was unpopular, as it was in the first case study, because, the students expressed, isomerism is an easy topic whereas the implication of 'evil' in the description also implies difficulty.

"you start to think that if it is evil then it's going to be hard - to understand".
Although the students recognised to what the next sample alluded, they felt that the description was not helpful because of the emotional connotation of boredom:

"its like the politics bit (mentioned earlier) only its religious education - you also tend to think religious education is boring so it follows for the chemistry".

The next two samples - 'bending a thick branch to cut it' related to double bonds and 'running up a down escalator' related to dynamic equilibrium - were popular with the whole group. The students felt that they could imagine themselves doing these things which they felt aided their understanding and ability to link in the properties of the concepts.

The rugby analogy for equilibrium seemed to be understood by all four of the students although one young lady wondered if other girls would understand it. However, the others, including the young man, confessed to knowing very little about rugby itself but felt that a general idea was enough to get a picture to aid understanding the concept. The main thing they liked about the sample appeared to be its humour, which they felt made it memorable:

S1  "I mean - its funny so you can remember it"
S2  "You would probably remember it forever".

During the ensuing discussion on humour in the classroom, student 'R' thought that it "might take you off what you are doing ie. chemistry" but he qualified this by saying that humour does have a place in the classroom. The rest agreed.
"It breaks the monotony a bit - it could get a bit heavy going if you got three hours of just chemistry".

Since the students had not yet studied the topic from which the final samples came, the discussion continued into the general use of figurative language. There was general argument that it could be useful in explanations in chemistry:

"It's a much better idea if you can relate it to day to day things rather than just abstract ideas, you have a much better chance of understanding the subject and it makes it more interesting".

but that teachers should ensure that all the students have the knowledge on which a metaphor or an analogy is based:

"It would be better if they were about more general things than - like rugby - otherwise it's no use."

Overall, throughout the workshop, the students seemed well able to point out the benefits and disadvantages of the figures of speech used as samples, to discuss the relationships of properties when they recognised the topic of the description and to push metaphors and analogies to their limits when given the opportunity although many of the sample were novel descriptions to them. However, I did get a general impression that they were considered by these students to be somewhat unusual descriptions for inclusion in chemistry lessons.
6.4. COORDINATION OF INTERPRETATIONS FROM CASE STUDY 2

As with the first case study, there seemed to be a high degree of consistency across the views expressed by the teacher in grid elicitations and negotiations and in the interviews. In each there was an emphasis on his responsibility as a teacher to transmit specific information well. The discussions of modes of transmission from each source mentioned variety of presentation, linking new material to known concepts, the usefulness of humour and the necessity, in his opinion, of underlining the practical nature of his subject. In comparison to Mr. A, Mr. B. would seem to fit more nearly into the traditional style of teaching as described by Rogers (1980) and, in fact, at one point in the interview he described himself as 'being a subject-centred rather than student-centred teacher.'

This data from the teacher is supported also by the observations made during his lessons, in particular the sense of the teacher, the active giver: student, the passive recipient interaction in the classroom. This point was noted in more detail earlier where this teacher happily agreed that he enjoyed giving a performance to the students, although he definitely preferred a receptive audience. My observations early in the year noted that in the classroom a good working relationship had developed and the student interviews indicated that Mr. B. was seen as helpful and approachable. This may in part be due to his frequent use of informal language and his declared and observed
enjoyment in 'clowning around'. However, two of the students in interview expressed a desire to take a more active part in the lesson and to have the opportunity to use models etc. themselves.

It is also interesting to note two other possible links between the teachers methods and responses given by students. The teacher had mentioned that he tended to use question and answer sessions as tests or punitively, while I had observed the infrequency of student-initiated questions in the classroom and had suggested that there seemed to be concern in the interviews with providing the 'right answers.'

The second point concerns the observed infrequency of figurative language use in the classroom associated with a high frequency of use of models and diagrams. This may be compared with the apparent degree of student unfamiliarity with figurative language used as an explanatory tool described in the analysis of the workshop data in the preceding section. In the same section, it was also noted that the students frequently linked figurative descriptions to models or diagrams seen in the classroom. These links support the notion that student expectation in a subject, and perspective on it, is in some way influenced by the current or predominant mode of its presentation.

Although Mr. B. does occasionally use figurative language, the observations support the view which came out of the grid on
methods that this form of explanation is seen as taking a supportive rather than main role in conveying ideas and concepts. The nature of the figurative language used seemed to be mainly of the kind denoted as 'now traditional in chemistry' in the previous case study, or to involve short personified versions of statements which are then repeated more formally - "if its a bit on the greedy side x can get both electrons."

However, the functions which figurative language seemed to fulfill for Mr. A. were not neglected in Mr. B's lessons.

He too revealed a little of himself to his students in the form of anecdotes but these took the form of reminiscences about practical experiences linked to theory under discussion. Similarly he indicated links to other science areas by noting how chemical theory is used in them.

Much of his work with models and many of his demonstrations were used to serve several purposes, associated in the preceding case study with figurative language, namely i) to provide some form of pictorial image, ii) to act as a cue to memory and iii) to amuse the students, so keeping alive their interest. Again these contributed to an informal atmosphere in the classroom whilst the lesson was still very much concerned with the transmission of chemical information.
The use of models and demonstrations in this way seemed congruent with this teacher's style and his personal interest in the practical, useful function of chemistry. Once again, this 'natural' facility or 'preferred mode' in particular method of presentation of ideas appeared to successfully fulfil its stated objectives.
CHAPTER 7

SUMMARY OF DATA FROM OTHER CLASSES STUDIED
CHAPTER 7  SUMMARY OF DATA FROM OTHER CLASSES STUDIED

7.1.0. INTRODUCTION

In this chapter, the data from three other classes studied in depth will be presented in the form of summaries. These summaries will be in the form of condensed versions of the case studies, mainly omitting quotations and in depth descriptions since these would not add substantially to the arguments. However, participants own words indicated by inverted commas, will be used where possible to retain the flavour of what was said. The various sub sections used are similar to those used in the case studies e.g. class observations, teachers interviews etc. so that comparisons may be made across classes.
7.2.  **CLASS SUMMARY 1**

7.2.1.  **SCHOOL DESCRIPTION**

This was a sixth form college which served a large catchment area considerably overlapping that of the school in the case studies. At the time of the research, the accent in its own description in the handbook it produces is on a formal and disciplined approach to education. There is a strong accent on requirements such as 'appropriate' dress - although there is not a uniform per se there are strict guidelines about what is and is not 'appropriate' e.g. smart suit, shirt and tie for boys - and on 'decorous' behaviour 'befitting studious young adults'. The participants in education at this school are defined in the handbook as 'teachers' and 'pupils' although in this study the latter will be referred to as students as with the other case studies. From my own observation, the general atmosphere of this school was considerably more formal than either of the two other schools studied in terms of general deportment of students, concern with rules etc. although those rules concerned with dress had been reinterpreted by the students considerably more broadly than one might be led to expect. The atmosphere was not however oppressive, the students appearing to tolerate or accept the conditions as an extension of those from earlier schooling, overt signs of rebellion being few. The degree of formality varied considerably within the three different classes (defined by different teachers) that I initially visited, the atmosphere being the most relaxed in the class which took part in the study. All the students referred to teachers by their surnames and titles.
7.2.2. **CLASS DESCRIPTION**

The total number of students in the class was sixteen, comprising nine females and seven males. Their ages ranged from just 16 years to 17 years and all had come directly to this school after taking O levels in other schools. All had already gained an O level in chemistry except for one female student who had a general science qualification. Five students took part in the interviews for the study, three of whom were female. This class took part in the full range of investigation except for the final student workshop.

7.2.3. **DATA COLLECTION**

Unlimited access was allowed for classroom observation and this followed the same format as for the previous case studies. The teacher expressed great interest in the project and his interviews, grid elicitations and negotiations took place in his own private study. The formal constraints on the students timetables and private study periods meant that their interviews were conducted outwith school hours but took place in a small, comfortable room normally set aside as a technicians rest room. Invitations were issued to myself to join staff for coffee in the staffrooms. There was always a rather formal atmosphere in the staffroom, each group of teachers seeming to have their particular places to sit related to subject/discipline areas.
7.2.4 **TEACHER DESCRIPTION**

This teacher was the head of the chemistry department and also deputised for the Principal on some occasions outside the school. In addition, he was involved in presenting sessions on study skills in the general curriculum. His dress was always formal – suit, shirt and tie – but during the course of our association it became obvious that the students observations about the flamboyancy of his shirts were justified. He is referred to in this study as Mr. C.

7.2.5 **DATA INTERPRETATION**

i) **Observation of class lessons**

Analysis of four lessons transcripts and associated notes reveals the following recurrent points.

a) Lessons appeared very carefully prepared and organised – evidence from orienting signals given to students in preceding lesson; models, prepared transparencies, demonstration equipment, samples etc. always laid out in advance; homework related to lesson and further reading lists prepared as handouts or transparencies for inclusion at end of each lesson.

b) Each lesson combined a large variety of activities which
were well spread throughout the lesson. These activities included: teacher giving verbal explanation; teacher dictating notes; teacher demonstrating using models, experiments, samples; teacher joking, digressing by reminiscence and anecdote; teacher/student question and answer sessions; teacher/students devising 'imaginary' experiments; students performing 'mini' experiments or observing results of teachers experiments, (both visually and by handling the material); students doing calculations and exercises; students watching film loop or slides with teacher/student dialogue.

c) The explanation of a new topic area usually seemed to follow a fairly regular pattern. This might be summarised as follows:- links to previous topics area/s specified and progression indicated; historical background briefly covered and/or demonstration performed with student involvement; explanation of terminology involved, frequently with derivations of words used; main general explanation (fairly formal, as might be found in textbook); explanation repeated using models, diagrams, figurative language, use of metaphors and analogies frequent - averaging 14 per one and three quarter hour lesson, ranging from trivial to elaborate and extended examples; particular areas highlighted, often illustrated by further models, film loops, slides etc; areas of application and points of current interest discussed; clear set of notes dictated; linked to next area of study.
d) Students generally appeared alert and interested during expositions and demonstrations and joined in discussion, asked questions and performed activities with apparent willingness although some students appeared more ready, willing and able to be involved in this way than others who seemed more content to be passive observers. The teacher may well have been aware of this because he occasionally deliberately involved one of these in a discussion by direct question or gave them a specific task to do.

ii) Teacher interviews

The recurring themes in these interviews are listed below and it is noted that the teachers emphasis and demeanour during the interviews gave the impression that he was very concerned with his job and gave it a lot of thought.

Views of Teaching and Learning

a) "Education in a broad sense is very important - one is not just there to teach a particular subject in isolation."

b) Lessons should be interesting and stimulating to students.

c) Students have different abilities, interests, backgrounds and future plans therefore different depths, styles and methods of teaching required within a lesson - "sometimes even encouragement of rote learning is appropriate."
d) It is important to know students well and get them personally involved in lesson "particularly with this age group".

e) It is important to expend time and effort on careful lesson preparation so that ideas are logically and consistently interrelated. It is also important to incorporate some flexibility into the lesson to account for some students requiring additional explanations, demonstrations etc - "to put in little extras to lighten the lesson and to give a broader view".

f) It is important to use language which the students can identify with and understand but it is also important that students should learn to effectively communicate their ideas to the academic community.

g) Learning is an 'active' rather than 'passive' thing and requires involvement. During the interview he also expressed some discomfort with the syllabus and particularly with the exam system but said that he feels obliged to the students and their aspirations to act within its constraints.

Views on Science, chemistry in particular

Once again, this represents a summary of frequently expressed or accentuated ideas.
a) Science is fairly clearly divided into disciplines which differ in their degree of 'scientificness', physics being the most scientific, biology the least, with chemistry midway between. 'Scientific' appears to be related to "clear-cut answers", "cut and dried positions", "laws which govern and are obeyed". "Less scientific" seems to be associated with "open-endedness" and "supposition". It is noted that it is many years since he studied either physics or biology although he has recently become interested in environmental science and the interrelation of disciplines.

b) Chemistry is an important subject that everyone should know something about since it impinges very much on day to day living and is frequently pertinent to political and social issues.

c) Prefers to promote understanding but recognises that for some students some topics are difficult and may have to be rote-learned for exam.

d) Concepts change with new information, some people interpret information differently to form different concepts.

e) It is sometimes necessary to tailor explanations appropriately to levels of understanding.
Views on Figurative Language

The views presented here are a synopsis of comments made when discussing his teaching and views on education which relate to his use of figurative language among other techniques.

a) It is necessary to use language in teaching which is familiar to the students.

b) It is necessary to relate new concepts to things already in their range of experience.

c) Making comparisons to human relationships and giving abstract entities human feelings and motivations helps students make sense of ideas.

d) Figurative language adds another variation to explanations to account for different perspectives.

e) Humour adds interest to lessons.

f) Figurative language stimulates imagination.

iii) Teacher Grids

During the grid negotiations Mr. C. made many statements which reaffirmed what he had said in the interview, the main points of which are listed earlier in this section.
The analysis of the grid for 'Role as a Teacher' indicated a tension between the two main areas of his job as he sees it by showing a distinct clustering and separation of those elements concerned with the essentially academic components (e.g. teaching central core of chemistry and laboratory skills) and those concerned with giving a wider perspective on the world and teaching other things e.g. humanitarian principles. Similarly, the constructs showed a similar dichotomy between those constructs concerned with academic requirements, e.g. constrained by exams, and those concerned with personal importance and perceived effectiveness, and student interest.

In Grid 2 - 'Methods I Use to Put Across Ideas', the wide variety of methods of presentation again became apparent, two elements of particular interest being 'imaginary models', which is a term he uses to distinguish metaphors, analogies etc. from solid models, and 'make believe', which is a term used to describe both experiments conducted by speculation in the mind and imagination exercises such as "if you were an electron subject to these pressures and constraints what would you do?" These elements are given a high ranking on the constructs: - "gives more teacher satisfaction" "helps students relate to chemistry" and "is of particular use with difficult concepts". They also are the elements placed closest to the heuristic pole of a construct named "didactic lecturing - heuristic teaching."
iv) **Student Interviews**

For the purposes of this part of the study the students views, at the time of the study, on Mr C's lessons are summarised, along with their views on figurative language, wherever possible using the students own wording. These students will also be represented in the full summary of data from students, including their philosophies of science and of teaching and learning in Chap 8 Section 2.1.

**STUDENT S.L.**

Mr. C.: - is well-liked by the class; is a little reserved, "definitely the teacher", but approachable when in difficulties; personalises the chemistry; puts things in many different ways and is amusing; goes to a lot of trouble to explain words and help with ideas for remembering - this encourages student to make an effort also; provides formal summaries for notes.

Figurative language: -

humorous and 'lightens' the lesson; gives a better picture of what's going on, is good when a 'proper' description is not available; helps make sense of very abstract ideas.

**STUDENT S.P.**

Mr. C.: - good at explaining and "getting his message across";
class is always "with him".

Figurative language:

- good for initial basic explanations but prefers to "move on to more formal wording when concept understood."

STUDENT N.W.

Mr. C.: - makes lessons enjoyable and interesting.

Figurative language:

- helps to think of the abstract as more solid things; is similar to solid models in that it helps to provide a "3-dimensional image."

STUDENT C.M.

- teaches at the "right-level"; "portrays things easily" and explains well; everyone in class is interested and understands him.

- is "good fun" and helps concentration but solid models or diagrams better because they give a definite picture which "can easily be reproduced."

STUDENT M.L.

- Tells things in different ways so that "you suddenly see it", "makes you think about things instead of just
accepting rules and laws."

Figurative language:

"personification of the abstract" helps him to understand, be interested and "identify with chemistry", "helps if you can imagine a whole thing and then break it down into its parts rather than trying to learn the different parts separately," useful, like models, in moderation but too many would be confusing.

The main points made here seem to be that Mr. C. was popular with the class and was seen as good at explaining, whatever the students preferences are in explanations, and at maintaining interest. Figurative language was variously viewed but all the students could see some advantages in it, though there were some reservations. It is also noted from the transcripts that all the students identified specific or general use of figurative language in Mr. C's lessons.

7.2.6. COORDINATION OF DATA

There appears to be a good match between what was observed in the classroom, what the teacher revealed in interviews and grids and the students opinions. The teachers variety in modes of explanation seemed to be successful in that students with differing preferences or styles each seemed to gain understanding, interest and enjoyment in his lessons.
Figurative language appeared to be only one of several techniques used by the teacher but it fitted in well with his apparently strongly held views about communication i.e. that it should be a language understood by students and be linked to their experiences. It also accorded well with his attempts to stimulate imagination and make students think for themselves via "imaginary experiments".

It is also interesting to juxtapose this latter point with his views on learning - that it requires active involvement - and the classroom observation that students were required and encouraged to participate.

Similarly, that point can be compared with his view about chemistry, that it contains some supposition and is somewhat open-ended, and his view that people view and interpret things differently, which has a constructivist flavour. Finally, it came across strongly from the students that these lessons were interesting. This may be related to the variety of information that is presented in addition to 'the central core chemistry' as well as to the variety in modes of presentation. This is supported by the observation and by Mr. C's declared purpose as a teacher - to provide a broad education as well as chemistry information for the exams.
7.3. CLASS SUMMARY II

7.3.1. SCHOOL DESCRIPTION

This was a large comprehensive school with its own integrated VIth form, its catchment area overlapping a little that of the school in the case studies but abutting to that of the other school studied. The VIth form part also drew students from another comprehensive school in the area i.e. it was a 'joint' VIth form. The handbook produced by the school emphasised that although the VIth form students used the same facilities as the rest of the school, they also enjoyed special facilities as 'senior students' e.g. uniform was not compulsory, private study facilities were available and the students had their own common room for relaxing in, making coffee etc.

From my own observation, the atmosphere was more informal than the previous school discussed but less informal than that in the case studies. It seemed that staff deliberately tried to accord the VIth form students more status than the other pupils e.g. by using those terms 'students and pupils' but sometimes this appeared more difficult in practice than in theory, especially when a student had been known to a teacher from earlier years. The students deportment was generally relaxed and, although in the classroom teachers were referred to by title and surname, references were frequently made to their first names in informal discussions. From remarks made during classes and during the study of the two classes it appeared that
staff and students met informally fairly frequently in extra-curricular activities such as specialist clubs and school-run social events.

7.3.2 CLASS DESCRIPTION

This class had fourteen students, five of whom were females. Their ages ranged from 16 to just under 17 years. All had been pupils in this comprehensive or the linked comprehensive a few miles away and all had already got O level in chemistry. Since all the students were very keen to take part in the study, they were all interviewed and the class as a whole completed the full range of the investigation except for the student workshop.

7.3.3 DATA COLLECTION

Unlimited access was allowed throughout the school and the classroom observation followed the same format as for the case studies. The teacher and his colleagues expressed great interest in the investigation and encouraged many informal visits to their staff area which was very informally set out, coffee being continuously available whenever anyone felt like making it - each person had their own coffee mugs and a special one was provided for me to use during my time there. The school's career office was provided for my use whenever I wished to interview students but the teacher interviews and grid negotiations took place in a preparation room adjacent to the classroom.
7.3.4. **TEACHER DESCRIPTION**

This teacher was the head of chemistry for the whole school and also was involved with a project investigating an integrated science curriculum. He also helped run the school youth club in the evenings. He generally wore casual trousers and jumper under an unbuttoned loose lab coat. He is referred to in this study as Mr. D.

7.3.5. **DATA INTERPRETATION**

1) **Observation of class lessons**

During the frequent visits to this class, the very relaxed atmosphere was noted. Several lesson transcripts were analysed and a similar general pattern emerged in each which will be described as 'general structure of lesson' below. However it was noted on each transcript that there was continuously a great deal of student talk. This would make analysis of the lesson from the transcript alone extremely difficult. Fortunately, many notes were made during the observations which were also frequent so that the observer was very familiar with both students and teacher and the general classroom set up.

**General structure of lesson:**

a) previous lesson was quickly summarised, final threads of discussion drawn together by going over homework based on its work;
b) new topic was begun by stating relevance to earlier work and
giving general plan of work for this lesson;

c) problem posed related to topic area (e.g. "Have you ever
wondered why some reactions go as soon as you put the
reactants together whereas others might need some warming
up?")

d) teacher led a discussion by integrating further questions;

e) teacher allowed class to discuss factors and argue points;

f) teacher summarised main points and drew discussion to

  conclusion;

g) items c to f may be repeated several times though the method
of posing a problem varied e.g. by demonstrating a phenomena
and asking 'what's going on'. Also the teacher might clarify
points during the discussion by giving a demonstration,
showing models, telling an illustrative story, or
encouraging the students to do an experiment. Finally,
while summarising main points, a film might be shown, a
newspaper article read or practical applications described.
During one lesson a pop record about 'Piltdown Man' was used
as a stimulus to discussion about evidence and led to a
discussion of C 14 dating.

It should be noted that a single lesson observation of this class
might lead to an impression of a rather noisy and chaotic
lesson. The students seemed to do most of the talking and the
teacher occasionally darted off to fetch material, as it became
relevant to the discussion, in between noting main points of
discussion.
on blackboard as they occurred. However, the general pattern described as the lesson structure became apparent over the course of several visits and work on several lesson transcripts.

ii) **Teacher interviews**

This teacher took part in three interviews and expressed interest in taking time to do so because he felt it would be useful for himself as a teacher to sort out some of his ideas and to improve his teaching as well as for the research project. The main recurring points are summarised below.

**Views on Teaching and Learning**

a) He saw his job as being partly defined for him as "about making children jump through 'O' or 'A' level hoops".

b) He wondered if the science taught is really relevant to students future lives - it might be too theoretical or esoteric - "although I do try to make a good job of getting them to jump through the hoop, I'm not always sure its the right hoop."

c) A central recurrent theme for Mr. D. was interest, both his own and that of his students. "I know for a fact that if I'm not really interested in teaching a topic, I've not got so much rapport with the class, they don't get much out of it, they know I'm not interested so they are not."
d) Things that aid student interest which he liked to incorporate into lessons are "seeing and doing", "relating theory to what they read in the papers and see on the tele" and "putting what they learn in to the context of what's happening in the real world." He felt these things also helped them to remember and to enjoy their lessons.

e) "Making the children interested in learning things - it's what all teachers ought to be doing - I think you've got to be emotionally involved in teaching."

f) His job involved more than teaching his subject, chemistry. "there's educational qualifications and there's the old idea of the well-rounded man - I think you've got to have a blend of the two."

g) Some of the things in addition to chemistry that he tried to teach students are: "to be more cooperative and tolerant"; "to learn to work as part of a group"; "to appreciate another person's point of view."

h) He liked to use a wide variety of teaching methods, using those which seemed appropriate for the students at a given time - "you almost do it by reflex - it really depends on how I perceive they'll understand or are understanding the topic"; "there is a range between straightforward presentation of facts, through directed experiment, open-ended experiment, to discussion from them - it rather like ionic and covalent bonding cos there's so many variations of a trend between one extreme and another."

i) He hoped that he learned from his own teaching and would do "a damn sight better job each time I do it". 
He frequently emphasised rapport between him and the class e.g. "they know when I'm being serious and when I'm telling them a load of old rubbish just to entertain them."

**Views on Science, chemistry in particular**

He gave these descriptions of science: 

a) Science involves a field of knowledge which has some facts and logical deductions and often "involves intuitive leaps - our way of rationalising observations."

b) This latter aspect of science is only for "the few brilliant scientists" - most people involved in science are more concerned with its practical applications.

c) The practical applications component is especially relevant to chemistry which is "often more a service to technology."

d) Chemistry requires practical, manipulative skills and skills in theorising - "you can be good at one and not the other."

It is noted that Mr. D. stated several times that he would not consider himself as a theoretical chemist, that he had had difficulty as a student in deducing theory from raw data and had always been more interested in the applications side. It was therefore no surprise to him that he seldom found students who were good at and more interested in the "deductive side"
Views on Figurative Language

Throughout the interviews, Mr. D. frequently brought up the topic of language in teaching as something which concerned him. He quoted research from the area which he thought was pertinent and frequently gave examples from his own teaching experience. A summary of the main points he made is given below followed by some illustrative quotations.

a) Technical jargon is frequently confusing, e.g. the meanings of 'element' in different disciplines, and often uses unfamiliar, "grand" words when everyday words would suffice or be as good e.g. 'effervesce' and 'fizzy' - "why can't we speak plain English?"

b) Some concepts are so difficult that they need to be related to something familiar. He often had to do this for himself so he tried to do it for his students.

c) Different people need different kinds of explanation - "if you don't try and think of different ways of explaining it to suit particular people present you might as well not be there, just give them all a textbook."

d) Analogies are useful in different ways for different people - "Some, the most able, don't need analogies etc. although they may be amused by them, the middle ability find them useful for understanding, the less able may never get beyond the analogies but a simplistic grasp is better than none."

e) Care must be taken to try to get most students beyond the analogy to a deeper form of understanding and to being able
to communicate that understanding in a more scientific way. "I sometimes say, look this is an explanation in 'moron Mr. D. language' and then when they've got the hang of it we write it down in scientific language."

f) Figurative language is a personal expression and is context-dependent - "often what I say to them relates to what they know of me as a person - you couldn't use it in a book - do it by remote control - it wouldn't work."

iii) Teacher Grids

The elements chosen by Mr. D. as reflecting the various components of his job divide into three groups: those concerned with the traditional expectations of the teacher i.e. 'the passing on of information' and 'methods of reasoning' and 'developing practical skills'; those with a broader educational remit i.e. 'help the student understand the world' and 'to think for themselves'; those concerned with an emotional component in learning i.e. 'stimulating interest in science', 'passing on a way of looking at the world' and 'making science enjoyable.'

In this first grid there were strong indications that Mr. D. was most confident in his abilities to fulfil the first group of components in his job and least confident about his skill in those within the broader educational context. However, he indicated also that he made particular efforts in that area and that this was an area personally important to him as a teacher.
For the grid "Methods I Use in Teaching", the elements reflected the wide variety of methods used, four of them being things which the students do themselves e.g. 'students own practical'. These obviously scored high on the construct pole "teacher involved less" but interestingly also scored high on what the teacher "enjoyed least", and on what he felt were "of peripheral value to less-able students", and moderately high on what he felt "students like least".

Two elements of particular interest are 'official analogy' and 'Jackanory analogy'. The first term was used to cover figurative language commonly used in chemistry (e.g. solar system atom, the 'hill' analogy for thermochemistry) while the second term was used to cover more personal analogies, anecdotes and "funny figurative language" e.g. "those which might not really be an exact analogy - but lets have a bit of a laugh about it." The former he felt were quite central for explanations to bright pupils but of not a great deal of use to the less able, the reverse being true for the 'Jackanory analogy'. This latter also scored highly on "all students enjoy", "teacher enjoys", "central to teaching", and "particularly useful for difficult concepts." Similarly, the element "linking theory to practical or the real world" scored highly on "all students enjoy", "teacher enjoys", "central to teaching" and was seen as very useful for both bright and less able students. Notably also, the element "individual help" had an almost identical pattern of scores to "Jackanory analogy", the teacher explaining that the bright students and less able students needed both but for different reasons.
Student Interviews

As with the study of Mr. C., the views of the students of Mr. D. are summarised here, using the students own words where possible to describe Mr. D's lessons and figurative language. However, it should be noted that, of all the students interviewed in this research, these students were most articulate, had a lot of views to express and did so with willingness so that very little questioning or encouragement was needed from the interviewer other than "I am interested in how you see science, your thoughts on how it is taught or should be taught." These views are necessarily very much condensed versions from the lengthy transcripts from each interview.

STUDENT S.H.

Mr D.: "encourages us to talk about chemistry and describe it in our own way - language"; he admits when he found a topic difficult himself - "so that encourages those of us who are struggling."

Figurative language:

frequently gave anthropomorphic descriptions in interview; "I like to have something concrete to relate to or a picture to imagine"; it helps to put things into your own words or relate it to own experience.
STUDENT F.A.

Mr. D.: has a lot of variety in his lessons and "he likes to make them interesting" and "helps us to remember things"; often makes students laugh; "we are never bored in that lesson and we all seem to understand him"; he is very approachable and frequently gives help outside class hours to those in difficulties.

Figurative language:
relating to everyday things can be a help but can sometimes be distracting; it can stop boredom setting in; student only remembers useful analogies, ignores others.

STUDENT R.J.

Mr. D.: makes chemistry lessons much more interesting;
"gives real good descriptions."

Figurative language:
helps memory by being related to something familiar;
makes lessons interesting and amusing.

STUDENT P.F.

Mr. D.: very approachable with queries; "jollies class along";
makes chemistry more interesting and keeps lessons alive with odd jokes, unusual methods - "like when he played that record."
Figurative language:
good for helping to form a picture of the abstract
especially when its related to familiar things; helps
with memory; models are helpful in a similar way in
that "you can see structure".

STUDENT M.W.

Mr. D.: "he LISTENS and everybody listens to him"; "jazzes
boring bits up with bits of humour or something
unconventional"; always adjusts his pace to the
students understanding; responds to students questions;
makes lessons enjoyable.

Figurative language:
too much technical jargon at beginning of explanation
would confuse; likes things to be related to everyday
life - "it helps me to see things".

STUDENT S.I.

Mr. D.: explains well; "sometimes uses strange ways, sometimes
even silly ways but it makes it more interesting."

Figurative language:
student thinks he tends not to visualise things but
works things out by logic; prefers straight facts so
when its necessary to talk in the abstract "figurative
language can help pin it down."
STUDENT P.G.

Mr. D.: interesting to listen to because of use of imagination, jokes and relating concepts to familiar things; has given a lot of personal after-school tuition to make up for lessons lost during illness.

Figurative language:
understanding is helped by relating "the microscopic to larger everyday things"; funny things "stick in the mind" and make theory more interesting; like solid models they help to give a 3-D picture.

STUDENT R.W.

Mr. D.: makes things a lot easier to understand than the explanations given in textbooks; doesn't just give the theoretical version.

Figurative language:
own descriptions always given in figurative language first; "they provide a picture to refer back to when you have to work on the concept later".

STUDENT S.H.

Mr. D.: "explains really well"; "I like the way he relates things together - shows practical uses and so on."

Figurative language:
"helps to confirm the way I've already been picturing
imagining things"; like models, they are good for remembering; help support mathematical proofs which are also useful.

STUDENT S.A.

Mr. D.: "down-to-earth - not too far above you to be of help", "him having a laugh with you means you all enjoy the lesson"; makes a student feel confident and because, the teacher seems to be making an effort, he wants to please him.

Figurative language:
helps understanding; "its like having an example to refer to when something new crops up"; gives a 3-D image.

STUDENT J.S.

Mr. D.: helpful and makes lesson interesting; "sometimes mucks about when we could be getting on with work but I suppose it breaks the monotony for the others."

Figurative language:
"breaks the lesson up" and makes it more interesting but not useful personally - prefers practical proof and mathematical explanations.
STUDENT K.M.

Mr. D.: makes the class relaxed, friendly and willing to join in; "spurs people to contribute, makes it more of a cooperative exercise."

Figurative language:
"helps to fix things in your mind"; adds interest; especially good if concept not conducive to being modelled physically or if it "is not very imaginable."

STUDENT D.J.

Mr. D.: "tries to make us think", "we generally work things out by discussion though I suppose he keeps us on the right track but we are made to use our minds - put ideas forward."

Figurative language:
"things that you can't actually see don't stick in your mind unless you have got something real to relate them to."

In summary, there was general agreement that Mr. D's lessons were interesting and enjoyable. There were frequent mentions of work being done as a cooperative enterprise, of students being encouraged to think for themselves and of the apparent effort of the teacher in providing appropriate explanations and individual help.
Except for one student, all of these students found figurative language personally helpful either for picturing things in the mind or for aiding memory. There were frequent references to the humour involved in this language form and three students particularly related its use to that of models. Many students saw it as a way of relating the abstract to the familiar and most described concepts using this language form or 'everyday language' although they seemed on the whole to also know the more technical version.

The view of these students on teaching and learning and about the nature of science, particularly chemistry, will be included in the full student summary in Chapter 8. However, it should be also noted that, as a group, they had quite firm, though differing, views on these topics and elaborated on them in more depth than any other group of student participants.

7.3.6 COORDINATION OF DATA.

There seems to be good general agreement between what was observed in the classroom, what the teacher said of himself and his methods and the students descriptions of the teachers style and what went on in the classroom. In each the high level of student activity and talk is mentioned. Although the teacher expressed some doubt about how well he gets students to think for themselves, the students frequently expressed this as one of the things they felt encouraged to do and the impression often given
was that they felt this was something peculiar to these lessons. From the observations and from the discussion of the student interviews, it seems likely that the teachers concern for language, that it is an important part of teaching and learning and that care should be taken to make it understandable to a variety of people, is reflected in the students ability to express themselves clearly and well and, indeed, in their willingness to present their points of view.

In 7.3.5. (1), it was noted that a superficial view might be that the lesson were chaotic, but the lesson analysis supports what was derived from the teachers interviews and grids, that there is always a general underlying plan which is tailored and ammended according to the situation and the particular students present. In addition, at no time did the students give any indication that they considered the lessons chaotic or disconcerting, on the contrary, they spoke of feeling confident and of all "being with" or "always following" what was going on.

Data from all the sources seems to support a description of the teachers style as being a personalised one, involving rapport between all class members, with a degree of use of unconventional methods.

It is also relevant to note that the teacher and his students used figurative language to describe chemical concepts, themselves, their teaching and/or learning and science in general. It may be that this has become the accepted or
'natural' thing to do, if only in the context of this class. It would be interesting to hear these students explanations in other subject classes to see if it is carried over or generally kept within the context of those chemistry classes.

The teachers expression of his philosophy of science, that for most people it is the practical side that is important, is reflected in both what he taught (content) and how he taught (methods used) since he linked the theory to practical applications in the world at large and to demonstrations and experiments performed in the classroom.

A strong general impression derived from this data is of a teacher very committed to teaching (the subject matter being in a sense secondary), this commitment being expressed in an affective, and in the students opinion effective, style of presentation of the subject.

7.4.0. CLASS SUMMARY III

7.4.1 SCHOOL DESCRIPTION

This school was the same one as described in 7.3.1. The study took place shortly after that in section 7.3. and there were no discernable differences in the philosophy or ethos of the school between the two studies.
7.4.2. **CLASS DESCRIPTION**

The total number of students in the class was seven, comprising six males and one female. Their age range was the same as that for the former class i.e. between 16 years and 17 years. All students had come directly to this sixth form after taking O levels in that school or the linked comprehensive and all had an O level in chemistry. The small number of students in this class as compared to that in the previous study was a reflection of time-tabling difficulties associated with particular subject combinations. Four of these students took part in the interviews, the female and three males. The class was observed on four occasions; the teacher took part in two interview sessions but completed no grids because she had to leave the school through sudden ill health. Consequently the full study was not completed.

7.4.3. **DATA COLLECTION**

The data collected in this curtailed study was analysed in the same way as those for the other studies although the supporting data from grids and student workshops was not available.

The classroom used for observations and the rooms used for teacher and student interviews were the same as for the previous study. The teacher expressed interest in the study and seemed happy to cooperate and afford the researcher the same level of hospitality as her colleague in the previous study.
7.4.4. **TEACHER DESCRIPTION**

This teacher was assistant to the head of chemistry. She had taught in several other schools prior to this one. Her dress might be described as 'smart-casual'. Usually she also wore a white lab coat. She was at that time pursuing a correspondence course to improve her expertise in related science areas. She is referred to as Mrs. E. in this study.

7.4.5. **DATA INTERPRETATION**

1) **Observation of class lessons**

Analysis of two full transcripts of lessons and associated notes revealed the following recurrent points:-

a) The teacher spent most of the lesson in the body of the classroom with the students except for when working on the blackboard.

b) The verbal interaction between the participants was generally informal in tone and character, there being no formal mode of address and the lesson being conducted in a conversational manner rather than as a lecture.

c) Most of the questions were posed by the teacher in a general manner i.e. they were seldom directed at specific people and several students would volunteer answers. Sometimes the students would disagree with an answer given by another student and inter-student discussion would ensue. Students also would say, without necessarily being asked, if they felt they had not understood an explanation.
On starting a new topic on two occasions, the teacher firstly used a question and answer session which established the background, or already learnt knowledge relevant to the topic area, and followed this by an explanation of a new concept and then led a discussion, mainly by teacher question and student answer, on the area. Finally the students would be asked to summarise the main points while the teacher wrote it on the blackboard for the students to note. This sequence was repeated until several new concepts had been covered.

On both occasions the teacher used many blackboard diagrams and drawings of a cartoon-like nature to illustrate processes and concepts and followed the verbal introduction to the area by a student-performed experiment relevant to the particular part of the topic.

During the experimental session the teacher talked to individuals about their understanding of what was happening in the experiment and there was continuous inter-student discussion and some joking and 'banter' between teacher and students.

During the explanations mentioned in d), the teacher used several metaphors and analogies and frequently referred to everyday experience or occurrence of the phenomena (e.g. sugar dissolving in tea)

The figurative language used was of 'a general human experience' kind rather than 'personal disclosure' kind found in some other classes.
i) Although everyday English was used in the explanation and the teacher accepted answers and discussions in that form, she did generally also refer to the technical words used in science as well as encouraging the students to reformulate their summaries using the technical terms which were frequently new ones to the students.

ii) Teacher Interviews

The recurring themes in these interviews are listed below with some quotations used to illustrate particular points.

Views on Teaching and Learning

a) Mrs. E. was interested in and enjoyed her subject and wanted to pass it on to others - "I like to impart my knowledge and enjoyment to other people and see what they get out of it."

b) She tried to make it as interesting and relevant as possible:
   "by relating it to everyday life really and show how we use it at home ...... thats why we bother to study it".

c) Her description of the general teaching method she used is:
   "pointing out patterns, relating them back to things they've already studied or seen in everyday life" ..... "a mixture of talking, blackboard work, getting them to DO things, getting them to think of different ideas and try to find the right one". She also pointed out that what she actually did in a particular lesson depended both on "how I feel when I
actually arrive" and on the particular students concerned: "sometimes you find you only get through half of it because you find it hasn't really clicked with them".

d) She spoke several times of basing work on current knowledge and then taking the students further by questioning so that they could work things out for themselves.

e) When talking about explanations, she reiterated that she liked to use the blackboard and present ideas diagrammatically.

f) On a similar theme, she said that often if she had tried several versions of an explanation but felt that one or two still did not understand, she would encourage other students to explain in their own words - "sometimes if another student explains it, it becomes clearer".

g) She frequently expressed the idea that she did not mind if technical language was not used, except that it was economical for writing - "I'm not bothered about using set book phrases - scientific jargon isn't essential although it does sometimes save using ten words when one would have done." However, she was concerned that sometimes students could verbally demonstrate understanding but found difficulty in expressing it in written form, mainly because of time constraints.

Views on Science, chemistry in particular

The following views on science were expressed:
a) Science is not totally objective - "the deeper you get into it the more subjective it becomes." Similarly, concepts generally "are just models really that fit the evidence."

b) Chemistry interacts and overlaps with the other sciences.

c) Chemistry is particularly interesting because of its practical uses and because of its involvement in the world around. "We can put it to use to help ourselves industrially and in the medical field." "We are a collection of chemical reactions ourselves - and they're going on all around us."

Views on figurative language

Mrs. E. said that she used figurative language, particularly analogies, for two main reasons. The first is that she needed them herself to understand and remember. The second reason is because she felt that the students "like to think in solid terms really - they see atoms as bonded together with little sticks for instance."

"quite a few like to have a concrete analogy to use but some people are just prepared to accept abstract ideas."

iv) Student Interviews

All four students used very descriptive language, i.e. figurative language and lots of examples, when discussing their views. They also would give a technical term and then a brief alternative explanation in other words.
STUDENT M.S.

Mrs. E.:— student said he had no problem understanding the lessons as everything is clearly presented.

He found the parts about "putting theory to use is most interesting."

Figurative language:—

when asked about explanations, this student returned to the theme of interest in the practical applications or everyday occurrences of the phenomena.

STUDENT J.M.

Mrs. E.:— She (J.M.) appreciated the informality and teachers apparent effort to explain 'why' and show the links between ideas and between "chemistry and everyday things". Also liked "finding my own solution and working out links."

Figurative language:—

this student described some chemical concepts in terms of the metaphors and analogies used in the classroom but expressed a preference for "logical descriptions with every little piece in".

STUDENT N.T.

Mrs. E.:— Student enjoyed the stimulation of the discussion sessions — "I like puzzles, working things out, playing around with ideas"
He also liked the way the chemistry theory was related "to how the body works etc. - it makes it interesting and relevant".

Figurative language: -

He expressed the idea that he used models derived from these descriptions all the time although he realised that they were just models - "even though you know that it doesn't look like that in reality you tend to think of it and use it that way". Useful for understanding and memory.

STUDENT M.R.

Mrs. E.: - He said that the teaching so far had been 'pretty convincing' - he could understand why people want to know about chemistry - "its interesting especially if its actually putting something to use."

Figurative language: -

He preferred to build a solid model - "or do an analogue experiment" but if this is not possible he felt that such descriptions were essential" to have a picture in the mind to refer back to". He felt this is for understanding and also useful for remembering.

Overall, these students seemed to recognise that they were being given an opportunity to 'think for themselves' and they generally found this an interesting exercise. All the students mentioned the practical applications of chemistry or its relationship to "everyday life."
Different preferences were expressed about figurative language as opposed to other methods of explanation but three of the students felt that it had some value for them.

7.4.6 COORDINATION OF DATA

It is salient to note that although the lesson observation analysis was done sometime prior to the teacher interviews, the teaching methods used were described in very similar terms. The teacher expressed that her intention was to link new concepts to old knowledge, to show its relationship to the general environment and to draw out ideas and deductions from students. These were things she was observed to do and the latter two were confirmed in the student interviews.

Similarly, there was congruency between her expressed preference for using many diagrams and figurative language in explanations and her observed use of the same. Again the student interviews suggested that both of these were useful to the students, if only in that they could recall these explanations at a later date. This also confirmed the teachers impression that the students would verbally express their knowledge of chemistry and it was interesting to note in this context that the students frequently gave the technical term and then explained it in other ways.

This links with the teachers concern with their ability to use 'chemistry jargon' and with the observers impression that attempts were being make by the teacher to convert informal
expression to the more concise chemical terms during the summaries of discussions in the classroom. In a similar vein, the results of an experiment were described by a student as "a rusty sludge" - the teacher, by discussion of the properties of the substance, gradually converted this to a more scientific description - "a brown-red gelatinous deposit" - for inclusion in the notes.

Although the general atmosphere was friendly and relaxed and the students readily took part in the discussion sessions, other evidence suggested a more obvious dichotomy between the teacher and the students than was shown in the previous study of a teacher and class in the same school. This evidence includes those from the observation, that questioning was generally teacher-produced and that figurative language was of an impersonal nature, and that from the student interviews in which they described their appreciation of the teaching methods used but at no time spoke of personality characteristics of the teacher.

The students in interview also frequently spoke of 'relating things together' and 'having something to relate concepts to'. This may reflect the teachers interest in seeing relationships between the sciences and between science and everyday experience. It may also be relevant to her mode of presentation of explanations in that students are given diagrams, pictures and figurative language (possibly mental pictures) to which to relate abstract ideas.
CHAPTER 8

CO-ORDINATION OF RESEARCH DATA AND RESULTS
CHAPTER 8  COORDINATION OF RESEARCH DATA AND RESULTS

8.1.0  COORDINATION OF ALL TEACHER DATA

8.1.1  DESCRIPTION OF DATA COORDINATION

The data gathered from all five teachers who took part in the research was coordinated and summarised in Table 1 (overleaf). Since this is necessarily a radical condensation of the data, obtained by many rereadings and highlighting of the full data, only the main, more obvious points are noted in an attempt to gain an overview of the teachers’ perspectives on science, their main teaching concerns, their lesson styles and their main method of explanation. The general school ethos is also included in the table to provide contextual background.

It should be noted that although similar aspects of a particular area are noted (e.g. student participation in lessons) no attempt has been made to uniformly categorise descriptions in a particular dimension (e.g. either student or teacher dominant). Rather, an attempt has been made to retain the original, individual flavour of the data since this is likely to more accurately reflect the situation as it was found during data collection. (e.g. descriptions used are 'student-accentuated', 'interactive but teacher led, 'high level of student participation and influence').
<table>
<thead>
<tr>
<th>TEACHER</th>
<th>GENERAL SCHOOL ETHOS</th>
<th>PERSPECTIVES ON SCIENCE</th>
<th>MAIN TEACHING CONCERNS</th>
<th>GENERAL LESSON STYLE</th>
<th>MAIN METHODS OF EXPLANATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mr A</td>
<td>Informal Accent on adult-adult relationships</td>
<td>Science: is accumulated wisdom; requires a particular approach and kind of mind; is functional/practical.</td>
<td>Good bilateral communication of information; encouragement of student participation in learning; promoting student interest and keeping them happy.</td>
<td>Informal, personal-empathic; student-orientation; joint problem-solving.</td>
<td>Large variety of presentation methods. Frequent figurative language, personal anecdote and imaginary experiments &amp; mnemonics.</td>
</tr>
<tr>
<td>Mr B</td>
<td>Informal Accent on adult-adult relationships</td>
<td>Science: provides fundamental explanations; is intrinsically interesting; has a high utilitarian, practical value.</td>
<td>Transfer of knowledge in as pleasant a way as possible. Maintaining student interest. Teacher should communicate well.</td>
<td>Teacher dominant but informal. Subject-centred. Provision of an entertaining presentation.</td>
<td>Accent on solid models and demonstrations. Infrequent figurative language.</td>
</tr>
<tr>
<td>Mr C</td>
<td>Formal Accent on teacher-pupil relationship</td>
<td>Science: images on all aspects of life - physically, morally and politically. Chemistry is more open to interpretation and therefore 'less scientific' than physics.</td>
<td>Education in a broad sense and exam-passing are equally important. Stimulation of student interest and active learning. Bilateral communication of information is important.</td>
<td>Interactive but teacher-centered. Equal emphasis on student and subject. Tailoring explanations to the receivers.</td>
<td>Large variety of presentation methods. Equal accent on solid models, imaginary experiments, figurative language, all fairly frequent.</td>
</tr>
<tr>
<td>Mr D</td>
<td>Informal Accent on teacher-student relationship</td>
<td>Science: is a combination of the theoretical, the intuitive and the practical. The practical side is usually dominant.</td>
<td>Educational qualifications and personal development equally important. Emphasis on active, enjoyable learning. Bilateral communication is important.</td>
<td>Very informal,.hist student-teacher rapport. High level of student participation and influence. Co-operative learning.</td>
<td>Large variety of activities, some unconventional. Very frequent figurative language.</td>
</tr>
<tr>
<td>Mrs E</td>
<td>Informal Accent on teacher-student relationship</td>
<td>Science: provides models to fit the evidence; is useful to all aspects of life.</td>
<td>Passing on of knowledge and sharing of its enjoyment. Stimulation of student thought. Showing relationships among sciences and everyday life. Bilateral communication is important.</td>
<td>Teacher-led conversational. Encouragement of student activity. Involvement with science. Provision of links between the abstract and the more substantive.</td>
<td>An equal distribution of fairly frequent drawings and diagrams and figurative language with some individual student experiment.</td>
</tr>
</tbody>
</table>

RATIONAL FOR USE:

- **Main Methods of Explanation**
  - Figurative language and anecdotes aid understanding of the abstract; link new knowledge to old; aid memory; are amusing; add interest; aid rapport. They are of different use to different students.
  - Solid models and demonstrations aid understanding of the invisible; aid memory; provide amusement; aid interest.
  - Solid models and figurative language aid understanding; link new knowledge to old; aid memory; add enjoyment and interest; provide different perspectives.
  - Activities and figurative language encourage participation and active learning; are of value in different ways for different students; stimulate imagination; are fun.
  - Drawings, diagrams and figurative language give the students something to relate to and are essential to most for visualising the abstract.

NOTES:

- Bi-lateral communication = teacher → student → student
- Multi-lateral communication = teacher → student → student
In spite of variety in descriptive terms and also the small sample size, some patterns are discernable in the data (see next section). Thus, the overview with reference back to the main body of the data enables some of the questions posed in Chapter 2 to be answered.

8.1.2. PATTERNS FOUND AND QUESTIONS ANSWERED

Q1. "Is figurative language used as an explanatory tool in science lessons?"

From the data it appears that figurative language is certainly used in chemistry lessons although its degree of frequency of use is very different for different teachers.

Q2 How do teachers' philosophies of teaching and learning and the nature of knowledge relate to the use made of figurative language:

a) in terms of frequency of use:

b) in terms of mode of presentation;

c) in terms of purposes they expect it, or intend it to serve?

The comparative range of frequency of use of figurative language is:-- very high frequency - Mr. D; high frequency - Mr. A; moderate frequency - Mr. C. and Mrs. E; low frequency - Mr. B.
All of these teachers saw their jobs as having at least two important components i.e. helping the students to pass exams on the subject and making the lessons enjoyable. However, the pattern for frequency of use is mirrored by the pattern of 'level of student activity and influence in the lesson.' A similar pattern also emerges for 'concern about communication' in that for Mr. D. the students ability to express ideas is highly emphasized whereas Mr. B. is concerned that the teacher should communicate well and noted that he was sometimes disappointed in the students ability to communicate, which he felt they should already have learnt to do. The remaining three teachers seem almost equally concerned about their students ability to convert their understanding from verbal, everyday language to the written technical language of science.

When considering personal teaching style, the most frequent users of figurative language, Mr. D. and Mr. A, emphasize rapport or empathy and high personal involvement with the class and lessons. The lessons for them are centred around the students whereas the moderate users of figurative language, Mr. C. and Mrs. E, place equal emphasis on students and subject, while Mr. B. a low user of this language form, is very much more centred on the subject.

No relationship could be discerned between the teachers views on the nature of knowledge and their use of figurative language although they might be seen to range in philosophy from somewhat
'accumulated fragmentalist' views to more 'constructivist' views. All the teachers stressed in interviews and in the classroom that chemistry has a high practical value. One point of note, however, is that Mr. B. spoke of science as providing fundamental explanations and being intrinsically interesting. He also spoke of "maintaining student interest" in lessons and expressed surprise when they could not perceive its inherent interest whereas the other teachers spoke of aiding or stimulating student interest in the subject.

In terms of mode of presentation both the teachers with a 'personal' teaching style (Mr. D. and Mr. A.) used analogies, metaphors and stories which reflected their own personal experience, i.e. disclosed something of themselves, and they both used similar descriptive methods in normal conversation i.e. it appeared to be a natural mode of expression for them.

Both Mr. C. and Mrs. E. used more generally based figurative language, i.e. referring more to human experience in general, and seemed to use figurative language as an explanatory tool in more particular circumstances, both in lessons when students were having difficulty with an idea and in normal conversation when trying to express a difficult perspective. In lessons, Mr. B's use of figurative language was generally confined to traditional analogies and the occasional anthropomorphic word used as an aside or joke. In interview conversation the only figurative language used was the recurrent 'acting' metaphors used in connection with his teaching style and methods.
In terms of purposes which they intend figurative language to serve, Mr. A, Mr. D. and Mr. C. all express a wide range of purposes and expect that different students will find it useful in different ways or that it will provide different perspectives. Each also allocates similar purposes to other methods they use i.e. respectively anecdote, activities and solid models. Mrs. E. intends it to serve a more restricted set of purposes but again uses another method, drawings and diagrams, to serve the same purposes. The use of solid models and demonstrations by Mr. B. seems to share purposes in common with the use of figurative language by the other teachers.

It is notable also that only the two most frequent users of figurative language, Mr. D. and Mr. A, mentioned the possible problems associated with using it. Mr. D. spoke of the possibility of the analogy etc. being accepted as fact and suggested that it was necessary to take the students beyond the analogy to a deeper understanding. Mr. A. recognised the possibility of metaphors and analogies being taken too far, suggesting that their limits should be explored and not left for the students to deduce and to possibly consequently become confused.

From this evidence it seems possible that particular concerns in teaching, teaching style and personal facility and inclination in language influences the degree of use and mode of use of figurative language to some extent. Views on the nature of knowledge do not appear to exert such an influence except
perhaps indirectly where there is a link between own view, expected student view and consequently concerns in teaching.

The general ethos of the school does not seem to have any effect on the degree or mode of figurative language use, there being a high and low user in one school and a very high and moderate user in another. There may be a small indirect influence through constraints of formality/informality on the teachers general teaching style but the small number of teachers participating in this study make this difficult to assess, particularly since each was a willing volunteer (further implications of this will be discussed in Chapter 9.1. - 'Implications and consequences of the research methodology).

8.2.0 COORDINATION OF ALL STUDENT DATA

8.2.1 DESCRIPTION OF DATA COORDINATION

The data gathered from all of the 34 students interviewed is coordinated and summarised in Table II in Appendix IV. As with the data from the teachers, this is necessarily a radical condensation of the data in which only the main, more obvious points are noted in an attempt to gain an overview of the students views on science, views on their own learning and references to the usefulness of figurative language for them.
From Table II, two further tables were compiled, Tables III and IV, p. 8-9 and p. 8-10, which compare firstly the frequency of expression of particular views on science with the frequency of mention of particular personal benefits of figurative language, and secondly, the frequency of mention of particular views on own learning with the frequency of mention of particular personal benefits of figurative language.

It should be noted that the figures in the totals columns of both tables are used only to provide comparison between particular perspectives. For example an individual student may have mentioned the use of figurative language for aiding memory and spoken of science as both logical and for findings things out. Thus, 'aids memory' would have been scored on two occasions on Table III. (It should also be noted that when a student described different disciplines in science (e.g. physics and chemistry) as having different properties, then the description scored was that for chemistry since that is most relevant to this study.)

In spite of the complexity caused by the use of different phrases and their combinations, some patterns were discernable in the data, which help to answer Question 3 (b) from Chapter 2.

Comparisons of the summary of views obtained during the two student workshops and from the coordinations of data from each class studied, shown in Table V, p. 8-14, are used to suggest answers for Question 4 from Chapter 2.
<table>
<thead>
<tr>
<th></th>
<th>Total</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
<th>13</th>
<th>14</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Benefits Mentioned**

- Good for Initial
- Explanation
- Makes Teacher
- Approachable
- Aids
- Memory
- Provides
- Assistance
- Aids
- Understanding
- Aids
- Interest
- Provides
- Aids
- Navigates
- Provides
- Builds
- Confidence

**Studying VIEWS ON SCIENCE COMPARED WITH MENTIONED BENEFITS OR FIGURATIVE LANGUAGE**

**TABLE**
<table>
<thead>
<tr>
<th></th>
<th>Table A1</th>
<th>Table A2</th>
<th>Table A3</th>
</tr>
</thead>
<tbody>
<tr>
<td>85</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>10</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>20</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>8</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>7</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>20</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>13</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>7</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

**Table A1**

- Good for initial explanation
- Provides Aids
- Provides Confidence

**Table A2**

- Makes Teacher more Approachable
- Increases Aids for Understanding
- Increases Interest

**Table A3**

- Relates to Prior Learning
- Provides Mental Image
- Provides Memory

**Benefits Mentioned**

- Students view of own learning compared with reported benefits of figurative language
8.2.2. PATTERNS FOUND AND QUESTIONS ANSWERED

Q3. How do students philosophies of teaching and learning and the nature of knowledge relate to:

(a) how they perceive and receive the figurative language used by the teacher;

(b) the use they make of it in their learning.

From the discussions with students it appears that how they perceive and receive this language and the use they make of it are related in that they may perceive it as funny, laugh at it and remember it because it was funny and made them laugh. Thus the terms used when discussing figurative language may be taken as indicative of a combination of perception, reception and use. The terms 'mentioned benefits' is used in Tables III and IV to subsume these three aspects. Similarly, 'mentioned disadvantage' will describe the problems that students mentioned in connection with the teachers use of figurative language.

In this study, "views on own learning" is felt to reflect on an aspect of their philosophy of teaching and learning which is most salient to them although they may recognise other students as having different views and preferences. Similarly 'views on science' is taken to be indicative of their philosophy of the nature of knowledge within this particular context with its focus mainly on the chemical branch of knowledge.
From Table III, the most notable features are the large numbers of benefits of figurative language mentioned by those who thought of chemistry as 'theoretical/abstract' (21), 'practical/useful' (19), 'finds things out'(20) and 'may be proved wrong/mysterious(17). The particular benefits which scored most highly on this table are 'provides mental image' (22) and 'aids memory'(18), with 'aids interest'(14).

From Table IV, the most notable features are the large numbers of benefits of figurative language mentioned by those who 'have to understand'(20), who 'like discussion and/or variety of presentation (20) and who 'prefer to work things out/look for patterns'(13). The particular benefits which scored most highly on this table were 'provides mental image'(20), 'relates to the familiar' (16) and 'aids interest'(14).

From this it could be deduced that the most universal benefits of figurative language perceived by students are that it 'provides a mental image' and 'aids interest'. There is also some evidence to suggest that students with differing views on science and own learning perceive and use metaphors differently. It is interesting to note that those who see science as 'logical/orderly', 'proven/laws obeyed' with 'much to remember' find the least benefit from figurative language as do those who 'prefer rote learning', 'like to be given proof' and 'accept what told by experts.' There is suggestion here of a less mature, passive approach to learning with a relatively simplistic view.
of knowledge whereas those who derive most benefit from figurative language tend towards a more active approach to learning and perhaps a more complex, relativistic view of knowledge.

In the interviews, the most frequently mentioned disadvantages of figurative language are that it can be confusing or distracting. The total frequency of mention was low and its distribution across views about learning or knowledge fairly evenly spread so that there appears from this data to be no specific linking of views and experienced disadvantage.

8.3.0. COORDINATION OF DATA FROM ALL CLASSES (TEACHERS AND OWN STUDENTS)

8.3.1. DESCRIPTION OF DATA COORDINATION

A table was drawn up, table IV (overleaf) to compare classes i.e. each teacher and his/her students. It contains a summary of the teachers' frequency of use of figurative language and its main mode, other methods used in explanation and declared intended use of figurative language. This information was derived from classroom observation and from the teachers interviews and grids. The table also contains a brief review of the students views related to figurative language derived from their interviews and a summary of information derived from the students workshops where these were conducted. This again enabled a question from Chapter 2 to be answered.
RAW TEXT END
8.3.2 PATTERNS FOUND AND QUESTIONS ANSWERED

Q. 4. Is there congruency between the teachers intended use, mode of presentation and students perceptions, reception and use of figurative language and/or are there any unintended or unexpected repercussions in its use?

A study of table V, with reference back to the main body of the data indicates that although individual students speak about and use figurative language differently, and this may be in some way related to their approaches to learning and views about knowledge (Section 8.2.2), some congruency within classes is observable.

It was noted in Case Study 1 (Chapter 5) that the students of Mr. A. associated figurative language with mnemonics and other memory aids since they had properties in common for them. It was also pointed out that Mr. A. made particular efforts to suggest aids to memory to his students so that they may have become alerted to this use for figurative language. It was also notable that this teacher used a form of this language which revealed his own personal history and experience. He saw this as an aid to empathy in the classroom. In turn, the students reflected this in describing him as a friendly, approachable helper. Finally, Mr. A. expressed some reservations about figurative language use which were similarly expressed by his students in their workshop.

In Case Study 2, (Chapter 6) it was again noted that Mr. B's view, that figurative language plays a supportive role to models and
demonstrations, is echoed in the students' linking of the properties of these aids to explanation. In addition, the impression given in the workshop that figurative language is an unusual form of description in chemistry may well be a result of the students low experience of its use in their current chemistry classes.

The students of Mr. C. also linked properties of figurative language to those of models which are also frequently used in their lessons but they also stressed its role in making sense of, and aiding imagination of, the abstract. In comparison, Mr. C. stressed stimulation of students imagination as one of his aims, along with helping them to make sense of abstract concepts.

Similarly, Mr. D's encouragement of class discussion by deliberate use of common language and relationship to experience is reflected in the students perception that figurative language, among other things, helps discussion of chemistry in their own words and that chemistry is related to their own experience. As with Mr. A, Mr. C, who also uses personal experience referents in his figurative language, is seen as approachable and as a helping friend by his students.

The design declared by Mrs. E. to show her students the relationship between sciences and between science and everyday experience is noted in the lessons observations. Again, figurative language is seen by her as giving the students something concrete to relate to while the students link the two by describing
figurative language as similar to knowing of practical applications etc. in that they both give them something to relate to in chemistry.

Thus it appears that the way that a teacher uses figurative language and other methods in explanations has some general effect on the way that students perceive and use these explanations although for individual students personal preferences in learning and views about knowledge interacts with this to produce a variety of individual differences beneath an apparent consistency.

This study was conducted within a particular context, its focus being on chemistry lessons. The students discussed their views and use of figurative language within this context with reference to a particular teacher and style of presentation. This raises several related issues which may be termed unintended or unexpected repercussions in its use:

i) Does a particular style of teaching a subject and a particular mode of presentation of explanation affect later perception of other styles and modes of presentation in the same subject?

ii) Do students hold the same views of figurative language when it occurs in other sciences or other disciplines?

iii) Do students who find figurative language a useful aid to understanding in one class transfer it for personal use to other lessons either at that period in time or later in their studies?
Information which pertains to these questions from this study is as follows. Students who experienced a wide variety of methods of explanation in these classes frequently spoke of how boring other presentations in the past had been or how 'O' level chemistry had been different to their current experience of 'A' level, mainly in that 'O' level had been concerned with learning facts whereas now understanding and thought, in addition to memory, were required. Although this may in part be due to the content of courses and to the exam system it may also be that their perceptions are heightened by experience of different presentation methods. If this is so retrospectively, then it may well be so prospectively also.

It was also apparent from student interviews that many students viewed the nature of knowledge in other sciences as different from or complementary to the nature of knowledge in chemistry. For example, in brief, physics and chemistry were viewed as one abstract and theoretical and the other concrete and practical or one as speculative and the other as factual. This in turn may affect how explanations in each are expected and received as well as the reverse, the way explanations are couched affecting how the science is viewed as an aspect of knowledge.

Another piece of evidence which supports this comes from teacher Mr. C. He spoke of physics, a subject not studied for many years, in positivist, pragmatic terms whereas he said that he had increasingly become aware of the speculative nature of chemistry. It would take a longitudinal study of students studying different disciplines taught in different ways to unravel this complex interaction.
Further, some of these students spoke of perhaps becoming teachers themselves. Since their teachers, notably Mr. A, Mr. B. and Mrs. E, spoke of the influence that their own teachers and their own ways of understanding had on their own current teaching methods then it is possible that transgenerational effects occur.

Other repercussions of the use of figurative language are those deleterious effects sometimes mentioned by students and teachers. Some teachers, notably Mr. A. and Mr. D, are alerted to these while others do not mention them. In summary these include:

1) confusion engendered in students when the topic is not within the realm of their experience;

2) confusion or inappropriate learning caused by inappropriate extension of the figurative language or by focusing on irrelevant attributes;

3) inappropriate learning caused by too literal acceptance of the figurative description or explanation;

4) omission of learning caused by students viewing figurative discourse as irrelevant or as mere entertainment and thus not attending to an explanation.

In addition to this, students in the workshops highlighted the possible problems which can occur if a figurative explanation is abstracted from its context. The preceding and superceeding discussions frequently frame the figurative language so that it makes particular sense only to those participating at the time.
In contrast to these caveats are the positive advantages of figurative language use identified in this research. These will be summarised in the next section which addresses Q.5, practical considerations and suggestions for the teacher.

8.4.0. PRACTICAL CONSIDERATIONS AND SUGGESTIONS FOR TEACHERS

Q.5. Are there any practical considerations and suggestions which can be offered to the teacher vis-a-vis the use of figurative language in the science classroom?

On the basis of this study, the following caveats are suggested:

i) the teacher must give consideration to whether the metaphorical or analogous concepts and examples used are within his/her students' domains of experience;

ii) care must be taken to frame the figurative language in an appropriate context, to signal its intended use, to guard against too literal acceptance or disregard because it is not recognised as an explanation;

iii) it may be necessary to explore the complications of the figurative language in order to define the limits of the analogy or metaphor so that there are no inappropriate extensions or focus on irrelevant attributes.

This latter suggestion does not imply that teachers should always prepare figurative explanations in advance nor yet does it
obviate the teachers spontaneous use of these figures of speech in moments of pedagogical inspiration when they see that their students are struggling to understand a concept. Rather it suggests that joint exploration, by teacher and class, of the implications may be a necessity. It may indeed be of value in refining the ideas of participants and as a stimulus to thought. This relates to the third advantage of figurative language use in the classroom presented below as suggestions to teachers on the basis of this study about why and how they might use it.

i) It provides an additional different, often stimulating, way of repeating or reinforcing proffered ideas.

ii) It provides a more pictorial method of presenting abstract material which may be difficult for some students to conceptualise - this is especially advantageous for concepts which do not lend themselves to modelling in a more concrete form.

iii) It can act as a stimulus to discussion, imagination, reasoning and hypothesis formulation for the students.

iv) It can relieve the tension inherent in very theoretical lessons, and also make them more memorable, because the often apparently incongruous pairing of ideas involved is a source of humour.

v) It can be used to link new ideas to old, familiar ones which again aids both storage and retrieval of information and also generates more confidence in approaching new and different perceptions of the world.
vi) The amount of self-disclosure, i.e. revelation of personal history, experience and attitudes, which often pervades figurative language can aid in building rapport between the teacher and the class, so that s/he becomes more approachable with problems.

vii) The perception of the teachers ability to discuss technical theories in more mundane or colloquial terms encourages students to translate information into more manageable forms for themselves, promoting greater understanding at the expense of the rote learning of sometimes apparently meaningless technical phrases.

It should be noted that the preceding suggestions, about both positive and negative aspects of figurative language, were derived from a study involving very experienced teachers. Each had developed a style of teaching which they felt was both satisfactory from the students point of view and comfortable to themselves in terms of their personalities and inclinations. Each used figurative language in different ways, to different extents, with different intentions and in conjunction with a variety of other methods.

Therefore, the main suggestion is not that figurative language can be a panacea for all ills or student struggles for understanding but rather that it should be regarded as one alternative among the many possible ways of presenting ideas e.g. by the use of solid models, anecdotes, animated films or
even by a piece of music. Which of these is most appropriate will be determined by: the nature of the concept; the nature, interests, experience and ability of the students about to hear it; the facilities available; the intentions of the teacher and, not the least, his/her skill in presenting a particular form of explanation. As was noted earlier, if figurative language is thrown into a lesson as an aside or an afterthought it is more likely to cause confusion than engender enlightenment. A teacher must be convinced of its value and/or be prepared to explore its relevance and limitations in order to be more certain that it will produce the desired response in students.
CHAPTER 9

DISCUSSION
CHAPTER 9 DISCUSSION

9.1.0. THE IMPLICATIONS AND CONSEQUENCES OF THE RESEARCH METHODOLOGY

9.1.1. PARTICULAR METHODS USED

Voluntary participation:
All of the participants in this study were informed in advance that it was instigated by an interest in explanations in chemistry - how they are given and received - and that participation would involve several weeks of observations and interviews which I hoped to record.

This had implications for the sample of participants who eventually took part. For the students it may have seemed to them to be another form of assessment of their learning although they were given reassurances about the confidentiality of individuals views. This may have been a great pressure on the seriously struggling students in particular who did not wish his inadequacies to the further revealed, even to him/herself. In practice, students covering the range of abilities in each class took part but this may have been a consequence of their confidence in their teacher as well as in the researcher.

For teachers such research may be seen as a threat or intrusion on their professionalism. To illustrate this one teacher, when discussing extraneous control of facilities etc. which might
limit methods of explanation, said "The classroom - this is my kingdom - what we do in here is up to me to a great extent." In practice, all the teachers who took part in the study were teachers of long experience who, although they may have expressed some doubts about particular techniques, were generally perceived to be confident in their overall teaching. This confidence may have been due in part to a history of successful examination results. It is not unlikely that this combination of experience and success had resulted in the fairly clear-cut ideas about teaching and the development of consistent teaching styles which are reported in the study. A study of novice teachers might not reveal such consistency as ideas are formulated, tried out and discarded or adopted. Further, not all teachers are confident in their abilities, regardless of experience, and this may affect their performance when observed and hence the results of a study, if it can take place at all.

To illustrate this, I will describe two teachers who initially said they may take part in the study but who finally did not for the reasons given.

The first teacher tentatively agreed to be observed for a few lessons "to see what it was like". These lessons gave the impression of being "teaching practice displays" in that every possible teaching aid seemed to be used - film loops, OHP slides, demonstrations, solid models etc. - while the teacher's observed disposition was very nervous and his students appeared very
constrained. Further discussion with the teacher revealed that some pressure had been brought to bear by the Head of Department for him to take part in the study - "it might be good for him". Since my brief was to investigate what normally goes on in chemistry lessons and not to improve the participants teaching directly and since the grounding philosophy of the research was that it was a cooperative exercise, then this teacher was released from his obligation in as kind a way as possible.

Work with the second teacher was also curtailed because of conflict with the research philosophy and restrictions on the research instruments to be used. He had agreed to be observed for several lessons while he thought about being involved in the rest of the research. His main technique during the observed lessons was to dictate from the textbook and write passages from it on to the blackboard. This indeed might have given an additional perspective to the study had the teacher not decided that not only did he decline from having his lessons recorded but he also insisted that he should be given access to his students' individual comments. Again, this teacher was tactfully left out of the main research.

Thus, two, perhaps important, variations on the teaching of chemistry are missing from this study. Although this does not negate the findings of the study, it does imply that the range of frequency of use of figurative language may be extended to cover 'no use at all'. This in turn has implications concerning
students' views on, and use of, figurative language in chemistry if they had no experience of its use or if they perceived a lack of confidence in it in their teacher.

OBSERVATIONS:

Results of the research support the choice of observation techniques in the following ways.

The notes taken during observations in conjunction with the full transcripts allowed for discrimination of different degrees of rapport between teachers and students. For instance, the transcripts alone, or a measure of duration and frequency of teacher/student talk, would not discriminate between the teacher giving an infrequently interrupted fully-prepared lecture and the teacher ammending his talk to suit his students non verbalised questions, worries etc. nor yet would it adequately discriminate between individual or general problems with concepts when the teacher responds to a question from the class by giving an explanation to the whole class or the individual student, immediately or later.

The technique of using many observations to inform the analysis of a particular lesson had several benefits. Firstly it allowed the observer to become familiar with the participants and vice versa which in turn mediated for naturalness and normality in the lessons used as data. Secondly, familiarity with the participants and several lessons aided the revelation of recurrent techniques and teaching strategies. Finally, it
provided a variety of examples of explanatory or other episodes for discussion with the teacher and students.

Two examples from the research illustrate how one observation only of a class could have produced misleading data. During one series of observations a teacher was requested by the department to provide assessment scores for the students for an unusual purpose (a particular research interest of a member of the department). Thus the teacher, and students, were constrained by this test taking up half of the class lesson - this teacher later revealed herself as not a great deal in favour of frequent tests. During another series of observations, the teacher had to change the plan of his lesson at the last minute when the lab technicians had a disaster with some equipment.

INTERVIEWS:-

The semi-structured nature of the interviews allowed the participants to introduce perspectives which may not have been revealed in a more structured format. As an example, one teacher revealed that it was important to him that the students like him. This might not have been an obvious or an easy question to ask or answer in a more formally formulated interview.

The lengthy nature of the interviews and their informality also allowed participants to reflect on, extend or clarify initial views put forward. It also allowed participants to indicate their own perceptions of relationships between views that they expressed.
The teacher mentioned in the previous paragraph, for instance, indicated that 'students liking him' was a reflection of his previous experience as a student, informed his philosophy of education and influenced his style of speaking and methods used in the classroom.

The final interviews with teachers also allowed them to clarify things which might seem ambiguous to an outsider, so aiding interpretation of the data.

REPERTORY GRIDS:

As was noted as a possibility in chapter 3.2 (d), the recording of the negotiation of grids provided much valuable data because, while in the process of devising and ordering elements and constructs, teachers elaborated on particular points made in interviews and gave explanations of techniques and incidents in the classroom.

The grids themselves allowed for a degree of assessment to be made about relative importance of ideas and methods as well as relationships between them being elucidated.

The teachers universally expressed enjoyment of the stimulation of thought that this method provided but this, along with the other techniques, has some consequences which will be discussed in 9.1.2.
STUDENT WORKSHOPS:

As well as providing the expected data about different students' views on and uses of different forms and presentations of figurative language these workshops proved to be interesting in another respect. During these sessions, the students not only expressed their views but they also argued with each other, explained things to each other and worked things out together, all in a very lively and interested manner. This suggests that this is a valuable research tool for investigating peoples' ideas and giving an indication of which are strongly and which are more superficially held. Perhaps more importantly, it also suggests that this peer-learning activity might prove a valuable educational tool, stimulating exchange of ideas and perspectives, reasoning and interest.

9.1.2 THE COMBINATION OF METHODS

This multiple perspective, reflexive methodology proved a productive research strategy in that:

i) each instrument provided data in support of that found by other instruments;

ii) all instruments provided hints and suggestions to be followed up by other instruments and/or further illuminated data gathered earlier;

iii) the various instruments combined to gave a variety of perspectives on particular incidents or concepts;
iv) the combination of data from all sources gave more detail and allowed for more supported speculation than the data from isolated research instruments.

However, this methodology is not without limitations. Two of these, also noted in 5.1.5., result from the combination of 'asked' and 'unasked' questions in the research.

The first is that undue emphasis might be placed on perspectives elicited by 'asked' questions if steps are not taken to counter this. An example of such steps is the checking procedure used in the final interviews in this research.

The second is that participants might express opinions which they feel are relevant to the research as they perceive it while suppressing those which they perceive as irrelevant to it. This is difficult to counter altogether but in this research an attempt was made to do so by presenting the research topic in as broad a manner as possible to the participants without misleading them i.e. it was described as being concerned with 'explanations in chemistry' rather than the particular focus of interest 'figurative language as explanation in chemistry'.

Another limitation which must be recognised is a product of the interaction which produced the verbatim transcripts - questions in the mind of the interviewer which originally defined the research and questions and ideas which developed during the
the course of the research. These latter are dependent on the interviewers skills in perceptive listening. Perceptive listening involves taking account of non-verbal cues to meaning, (tone, gesture, expression etc.), and being sensitive to ideas that are tentatively hinted at or are perhaps being avoided. The empathic interviewer must attempt to feel his/her way into the internal frame of reference of the interviewee as far as possible.

This immediately raises certain implications for the analysis, interpretation and presentation of data. Firstly, the researcher must acknowledge to him/herself that the situational context and personal intuitive theories colour interpretation. For instance, passages may be chosen from a verbatim transcript to illustrate and evidence another's 'intended' meaning. The problem is, to quote Hull:

"But they are evidence in support of interpretations rooted in the black-market of my own private understanding in the unpublishable 'second record' not in the documents of the case."  

HULL 1984 p.9

Thus, in analysing and presenting his data the researcher must confront difficult questions e.g. Is the feeling of warmth generated when the teacher, the class and the observer collapse in giggles over a particular incident any less evidence of class rapport than words transcribed from a tape-recording?

Further, selection of data necessary to convey to others the results of particular research questions also necessitates
the omission of perhaps extraneous information. This omission may clarify things for the reader but perhaps does less than justice to the teachers and the students, who are also people to whom the researcher owes a moral obligation.

In this research I have attempted to balance utility and authenticity by providing some verbatim transcripts, quotations and categorisations using the participants own words. I also discussed my own interpretations with the participants and have provided for the reader reasons for my deductions where possible.

Thus, these limitations also represent consequences to the researcher and to the other participants. There are other consequences to the participants also inherent in this methodology. Other grounding philosophies of research suggest that researchers should leave their 'subjects' as they found them. This methodology would seem to preclude this, some of the evidence being given below.

This information was obtained after the completion of each class study, when the classes and teachers were visited in order to thank them for their participation and help, but it is nevertheless relevant to a discussion of the methodology.
EFFECT ON THE STUDENTS:

Students who took part in both interviews and workshops revealed that they now thought more about descriptions and explanations presented to them and would feel more inclined to approach teachers and ask questions etc. if in doubt in the future.

EFFECT ON STUDENT/TEACHER INTERACTIONS:

One teacher expressed pleasure about the effect that the research had had on the class interaction. They had discussed the study together in a lesson after the research ended. They had talked about what they thought about it, what they had said in interviews and so on. Since that discussion the teacher reported that she had found that the students seemed more willing to participate with enthusiasm in activities, to discuss problems and to risk making comments and suggestions. This could be interpreted as the breaking down of barriers between students and teacher as a result of sharing a common experience.

EFFECTS ON TEACHERS:

It was noted in chapter 4.1. (e) that repertory grids were not conducted until after the class observations because it was suspected that in-depth thought about methods and styles on the teachers part might influence subsequent practice. It would seem that the study as a whole had this effect since several teachers
expressed a similar view, that they now thought about and planned explanations with more care. Only a follow-up study would reveal if these changes were permanent. However, there were also some particular consequences of the research methodology worth highlighting.

One teacher disclosed that he had realised, particularly after the grid negotiation, that really his main interest was in helping the struggling students to understand basic chemistry. This has particular implications for his own professional development because the promotion ladder, to which he had previously been committed, led away from younger, less-able classes towards older, more academic groups. Further, it led to less class contact time, his greatest source of interest and pleasure, and more administration time.

Another teacher revealed that the research and its methodology had made him realise that he was more interested in teaching and learning per se than in his subject area. The consequence of this is that he is currently contemplating becoming involved in research himself, perhaps leaving teaching altogether.

All of these effects carry with them implications and consequences for the researcher considering using such a concatenation of instruments for research. These might be summarised as responsibility and accountability for both the interpretation of his/her data and for possibly altering the interactions and perspectives of his co-participants. S/he should also be aware that methods which appear relatively unintrusive may have unintended repercussions.
For those with a background in science, one teacher, while discussing the effects of research, provided an apt analogy:

"It's like putting a thermometer in anything it's a constraint on the system and it will change."

As an addendum to the preceding cautionary notes, it is only fair to add that this research had other properties for me, analogous to being a parent, besides responsibility and accountability. Namely, it was stimulating, fulfilling and rewarding - as well as frustrating at times.

9.2. RESEARCH RESULTS IN RELATION TO THE LITERATURE REVIEW

This thesis began with suggestions that teachers should pay attention to the part that language plays in learning and that they should use strategies which foster the students' active participation in their own learning. Following the first piece of advice the study investigated a form of explanation which seemed to have potential, based on its apparent use in ordinary discourse, for fulfilling the criteria of such a strategy.

Since the study particularly focussed on chemistry lessons some of its results also have a bearing on the variety of perspectives on the theoretical value of figurative language in science presented in the literature (section 1.4).

To summarise these, while various writers from Aristotle to Duhem (1914) suggested that figurative language was inappropriate
in this field because of its propensity to distract from logic and argument, others, notably Black (1962), Hesse (1966), Schon (1967) and Sutton (1981), suggest that it promotes understanding, inspires hypothesis and extends theory. Particular results from individual students in this study would lend support to each of these theories. Some students did say that they were distracted or confused by some presentations of figurative language while others felt that it either helped or was essential for their understanding. In addition, there was evidence of teachers using figurative language to help their students to generate hypotheses or to extend their current theories by devising 'imaginary experiments' or by casting explanations in an 'as if' mood, as proposed by Vaihinger (1924).

Similarly, it was possible to identify in this study some of the advantages and disadvantages of figurative language to general learning proposed in section 1.5. While most students benefitted in some way by its use - perhaps it helped them to visualise abstract concepts or aided their memory of them - others were confused, especially if they accepted the mental model as fact and immutable or if they over-extended analogous properties between the model and the concept.

This study was able to make suggestions for teachers practice (section 8.4) which would help to ameliorate the disadvantages and improve the probability of accruing the benefits.
Other aspects from the literature, that different students receive explanations in diverse ways (e.g. Entwistle and Hounsell 1979) and that teachers with different pervasive styles explain in dissimilar ways (e.g. Fox 1983) were supported by this research. Since the research also suggests that figurative language is better presented with care and in a convincing manner and also because it is difficult in practice to discern which students will derive most benefit from such presentations, the implication is that explanations should be presented in various modes.

Looking at this same area from a different perspective, it was observed in this study that common properties, both advantageous and disadvantageous to learning, could be identified in various forms of explanation e.g. figurative language descriptions, the use of solid models and practical demonstrations, the relating of concepts to everyday experience. Again some teachers appeared to have greater facility with some forms of explanation than others while the students related to these explanations in diverse ways. This indicates that if teachers were alerted to the propensities of the possible explanatory modes, they could extend their repertoire appropriately and thus be better equipped to aid a divergent range of students in their understandings.

This, in conjunction with other results from the research, has implications for teacher training.
9.3. IMPLICATIONS FOR TEACHER TRAINING AND H.E. STUDENT LEARNING

It was proposed in the preceding section that it would be educationally useful to heighten teachers awareness of the values and limitations of different forms of explanation, including those using figurative language. An additional component of this, which it would benefit educators to be sensitive to, is the congruency observed in this study between the teachers ways of presenting explanations, and their expectations of these, and the manner in which students receive and use them. This has much in common with Ramsden's findings:-

"that students respond to the context of learning defined by the teaching and assessment methods of academic departments. Some departments and lecturers seemed to facilitate a deep approach while others used methods of teaching which forced students into surface approaches"

RAMSDEN AND ENTWISTLE 1981 p. 369

A further point of interest is that the 'deep approach' mentioned in that study is that defined by Marton and Saljo (1976) as involving the students active attempt to understand meaning, to explain evidence and to relate ideas to prior knowledge and experience i.e. some of the benefits attributed to figurative language in this thesis. It was also noted in this study that some teachers used figurative language to stimulate discussion and argument between students and that some students felt that this technique made them feel more involved with, and in charge of, their own learning.
All of these features indicate that the incorporation of discussion and practice of explanation of various forms, including figurative language, into teachers' courses, both trainee and in-service, would be of value. Not only would this introduce teachers to a wider variety of explanatory forms and help them guide students to more active forms of learning but it would also alert them to associated areas of communication. One such area, which would be emphasized by consideration of whether the students have the knowledge addressed in figurative language, is the ideas and concepts which students bring with them to the classroom. The general value of this is stressed by Barnes:

"If teachers understand the patterns of communication in their lessons they can take more responsibility for what their students learn."

BARNES 1974 p.20

That such course components might be of particular value to prospective science teachers is supported by Kelly's observation that:

"people who fancy themselves as scientists are very much afraid of being caught doing anything that is not recognised as scientific, and especially so if what they are doing has anything to do with their professional field"

KELLY 1969 p.153

This would be especially pertinent if remnants of the negative evaluations of figurative language in science noted in the literature (section 1.4) still exist.

Further, empirical evidence from this research supports Sutton's (1978) view that educational benefits to science lessons derive
from 'pushing analogy further', 'attending to alternatives', 'valuing capricious thought' and 'tolerating looser language.'

Perhaps more teachers should be made aware that:

"there could be in science lessons a time for precision and a time for playful imprecision."

SUTTON 1978 p.30

Another observation from this study was that figurative language was sometimes used to stimulate discussion and argument and to promote a 'deep approach' to learning in students, abilities whose value is espoused, if not always actively encouraged, in Higher Education.

Might I propose that some of the activities suggested as useful contributions to teacher training courses should also be incorporated into Study Skills courses for students on degree programmes?

9.4. IMPLICATIONS FOR FUTURE RESEARCH

In section 8.3.2. some questions were raised which derived from the results of this research concerning the variety of ways in which students received and used figurative language explanations and in particular how this was affected by its style of presentation. These suggest that further information about learning might be gained from research in the following areas:
i) the acceptability of various explanation forms in different disciplines;

ii) the effect of experienced teaching style on future perception of a subject;

iii) the continuance of use, or otherwise, of a perceived effective learning style in later contexts of study.

In addition, this research emphasizes the need to extend such studies into the field of Higher Education because many of the students who participated were studying 'A' level chemistry as a prelude to degree studies. It was noted that some of these students expressed a preferred mode of learning which might be described as 'accumulation of knowledge' whereas others stressed that 'incorporation of ideas for understanding' was important for their learning. A study of such students and how they fare when taught by lecturers with matching or contrasting teaching styles and forms of explanation might shed light on the study problems of students in Higher Education and perhaps also on high drop-out rates in the first year of study.

9.5. **THIS PILGRIM’S PROGRESS**

The beginning of this journey was marked by many signposts pointing in different directions. However, I eventually trod my own pathway in spite of the hills called Difficulty and the giant, Despair. What sustained me in my travels was that I
thought I knew where journey's end was. Having reached that place, I now see it from a different perspective. This is the end - but only of the prologue - many chapters remain to be written in this travelogue.

(with thanks to John Bunyan 1628-88)

"The first forty years of life give us the text, the next thirty supply the commentary."

ARTHUR SCHOPENHAUER
1788-1860
BIBLIOGRAPHY

London: Grant McIntyre Ltd.

American Psychologist 8: 315

Reading: Cox & Wyman Ltd.

BARNES, D. (1972): Language in Education
London: Routledge, Kegan, Paul

BENJAMIN, A. (1981): The Helping Interview
3rd Edition
Boston: Houghton-Mifflin

BERGGREN, D. (1962): The Use and Abuse of Metaphor -1
Review of Metaphysics 16
pp 237-58

in HALSEY, A.H. et al (Eds.) (1961): Education, Economy and Society
New York: Free Press

Developmental Psychology II
pp 415-423

Ithaca: Cornell University Press

American Journal of Sociology 71
pp 535-48

BOYD, R. (1979): Metaphor and Theory Change: What is 'metaphor' a metaphor for?
in ORTONY, A. (Ed.) (1979): Metaphor and Thought
Cambridge: Cambridge University Press pp 356-408
BROWN, G. (1978): Lecturing and Explaining
              London: Methuen

BROWN, R. (1958): Words and Things
              Illinois: Glencoe Free Press

              Journal of General Psychology 53 pp 21-8


BULLOCK (1974): A Language for Life
              HMSO

BURRT, E.A. (Ed.) (1939): The English Philosophers from Bacon to Mill
              New York: Modern Library

              Scottish Curriculum Development Journal (Autumn)

CASSIRER, E. (1946): Language and Myth
              New York: Dover

              London: Academic Press

DEARDEN, G. (1979): Student Learning and Teacher Intervention in an Undergraduate Engineering Laboratory.
              Unpublished Thesis, Surrey University

DENZIN, N.K. (1978): The Logic of Naturalistic Inquiry
              in BYNNER AND STRIBLEY (Eds.) (1978):
              Social Research: Principles and Procedures
              Longman in assoc. with O.U.Press

              University of Queensland mimeograph

DUHEM, P. (1914): La Théorie Physique
<table>
<thead>
<tr>
<th>Author(s)</th>
<th>Year</th>
<th>Title</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>EDWARDS, A.D. and FURLONG, V.J.</td>
<td>1978</td>
<td>The Language of Teaching</td>
<td>London: Heinemann</td>
</tr>
<tr>
<td>EKMAN, P.</td>
<td>1964</td>
<td>Body position, facial expression, and verbal behaviour during interviews.</td>
<td><em>Journal of Abnormal and Social Psychology</em> 68 pp 295-301</td>
</tr>
<tr>
<td>ENTWISTLE, N.</td>
<td>1981</td>
<td>Styles of Learning and Teaching</td>
<td>Chichester: Wiley</td>
</tr>
<tr>
<td>ENTWISTLE, N. and HOUNSELL</td>
<td>1979</td>
<td>Identifying Distinctive Approaches to Studying</td>
<td><em>Higher Education</em> 9 pp 365-380</td>
</tr>
<tr>
<td>FOX, D.</td>
<td>1983</td>
<td>Personal Theories of Teaching.</td>
<td><em>Studies in Higher Education</em> 8 no2</td>
</tr>
<tr>
<td>FROMM, E.</td>
<td>1951</td>
<td>The Forgotten Language</td>
<td>New York: Rinehart</td>
</tr>
<tr>
<td>GAGE, N.L.</td>
<td>1972</td>
<td>in WESTBURY AND BELLACK (Eds.) Research into Classroom Processes chapter 9</td>
<td>New York: Teachers College Press</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>London: Sage Publications</td>
</tr>
</tbody>
</table>
GREGORY, R.L. (1966): Eye and Brain
London: Weidenfeld and Nicolson

GUILDFORD, J.P. (1967): The Nature of Human Intelligence

Research in Education (Manchester) 11 pp 1-15

Indiana: University of Notre Dame Press

HULL, C. (1984): Between the lines: the analysis of interview data as an exact art
Research Intelligence BERA Jan. 1984, pp8-11

New York: Norton

Journal of Individual Psychology 20 pp 137-152

in MAHER, B. (Ed.) (1969): Clinical Psychology and Personality
New York: John Wiley & Sons

KONOLD, C.E. and WEIL, A.D. (1981): Analysis and Reporting of Interview Data
Paper for Cognitive Development Project
Dept. of Psychology, University of Massachusetts

KUHN, T.S. (1970): The Structure of Scientific Revolutions
Chicago: University of Chicago Press

KUHN, T.S. (1979): Metaphor in Science
in ORTONY, A. (Ed.) (1979): Metaphor and Thought
Cambridge: Cambridge University Press pp 409-19

LAKOFF, G. and JOHNSON, M. (1980): Metaphors We Live By
Chicago: University of Chicago Press
    Guildford: I.E.D. mimeograph, University of Surrey

    Amsterdam: North Holland

MACDONALD, B. and WALKER, R. (1977): Case study and the social philosophy of educational research
    in HAMILTON, D. et al (Eds.) (1977): Beyond the numbers game: a reader in educational evaluation
    London: Macmillan

    Review of Educational Research 47 no 4

    Lincoln: University of Nebraska Press

MARTON, F. and SALJO (1976): On Qualitative differences in learning I & II
    British Journal of educational Psychology 46 pp 4-11 & 115-127

    Harvard University Press

MEREDITH, G.P. (1972): The origins and aims of epistemics
    Instructional Science 1 no 1 March

    in ORTONY, A. (Ed.) (1979): Metaphor and Thought
    Cambridge: Cambridge University Press p 202

MINTZ, N.L. (1956): Effects of Aesthetic Surroundings
    Journal of Psychology 41 pp 459-66

OPPENHEIMER, R. (1956): Analogy in Science
    American Psychologist, 11 (3) pp 127-135
Interchange 13 no.4

European Journal of Science Education Issue 2 April volume pp 249-261

London: Academic Press

Science Education 66 (2) pp 195-209

Cornell University Press

POSTMAN, N. and WEINGARTNER, C. (1969): Teaching as a Subversive Activity
Penguin

Journal of Abnormal and Social Psychology 43 pp 142-54

in ORTONY, A. (Ed.) (1979): Metaphor and Thought
Cambridge: Cambridge University Press p 420

RAMSDEN, P. and ENTWISTLE, N.J. (1981): Affects of Academic Departments on Students' Approaches to Studying
British Journal educational Psychology 51, pp 368-383

RICHARDS, I.A. (1936): The Philosophy of Rhetoric
London: Oxford University Press

Oxford: University Educational Press

Anthropology and Education Quarterly 8 pp 42-49
<table>
<thead>
<tr>
<th>Author</th>
<th>Year</th>
<th>Title and Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>RIST, R.C.</td>
<td>1980</td>
<td>Blitzkrieg Ethnography: on the transformation of method into a movement.</td>
</tr>
</tbody>
</table>


VAIHINGER, H. (1924): The Philosophy of As If: A system of theoretical, practical and religious fictions of mankind London: Routledge, Kegan Paul


WATSON and CRICK (1968): The Double Helix London: Weidenfeld


WATTS, M., GILBERT and POPE (1982): Alternative Frameworks: Representations of School Children's Understanding of Science. Internal mimeograph - University of Surrey


APPENDICES
Dear

As a PhD student, I am currently involved with research into some aspects of the teaching and learning of 'A' level Chemistry. As a preliminary to that research, I feel it would be most useful for me to discuss my project with headmasters whose schools are involved with this course of study.

As an ex-chemistry teacher myself, and also a parent of a child currently taking 'A' levels, I am aware of some of the problems that schools face. In addition as a researcher I have been made aware of the paucity of research and help available in this particular field. I hope, therefore, that our discussion would be mutually beneficial in helping to clarify some of these issues.

I would be grateful if we could arrange a meeting at your convenience during the early part of the coming Spring Term. I have enclosed a FREEPOST self-addressed envelope which I hope you will use to contact me about (a) suitable time(s) and (b) date(s) when I may visit you in your school.

Yours sincerely

Ms P Denicolo

enc
T. Right, now let me just explain (diagram on OHP slide) the key is simply an on/off switch which either completes or breaks the circuit - the rheostat is just a variable resistance. ..... A is an ammeter to simply measure the current - now look at the diagram - imagine for the moment that I've got some, that I haven't got the voltmeter in position, that I've just got this external circuit here, I close my key, complete the circuit. If I look at this current, if I wind this rheostat up and increase the resistance of the external circuit, in other words I make it DIFFICULT for the electrons to flow around the circuit - if I do that - I suppose I'd cause a log jam at this end, I'd prevent them flowing around, the current level will FALL as I raise the resistance, the current, ..... if you like ..... the number of electrons which can migrate around the outer circuit gets less .....
Is that idea alright? - Now - if I can put in a simple sort of voltmeter, and there are such available, which I stick across there, which doesn't actually interfere with the external circuit, in other words, it doesn't take any current at all, the best way to measure a voltage without taking any current is to use a wheatstone bridge arrangement - yeh - (students nod) - you could also use valve voltmeters which take very little current which you can ignore. Now - what I'm saying is this - if you put a voltmeter between those 2 electrodes build up on this thing until the zinc is even more and more negative compared to the copper and as a result the voltage goes up, or the potential difference between the zinc rod and the copper rod goes up. (pause)

Now if you take it through to its logical conclusion - I think it logical - if you wind this resistance up to infinity i.e. you get a chopper and break the circuit, or you open the key or something like that so its got an infinite resistance there, the voltage that you now measure across the electrodes will be the maximum possible obtainable and that is called the E.M.F.
the electro motive force of the cell -
now - you can't measure it absolutely -
but we can measure it very closely, alright?

Let's have a look at the notes (referring to
handout) "if the flow of electrons is reduced
by increasing the resistance the potential
difference measured by the voltmeter between
the two metal electrodes increases". My
toytown explanation is because the electrons
pile up on the zinc and cause it to be more
negative......

"it reaches a maximum when no current flows"

...... thats an important statement that you
should try to remember. ..... "This
maximum value is referred to as the E.M.F.
of the cell. It can be measured when the
key is open with the aid of a high resistance
voltmeter, or better still, by using a
potentiometer". - Thats a wheastone bridge
type of device - alright - "From the
discussion above it follows that" and then
we have the statement "the E.M.F. of any cell
is the measure of the relative tendency for
each of the electrodes to release electrons
by forming ions in the solution".

refers to formal
language description
in notes.

links it again
to figurative
description.

memory note

Returns to formal
description interjecting
already known item
for new technical
term.
Checks general student understanding. Right - any points there - its usually a worrying section - any questions? (pause) Coffee's looming on the horizon, is it?

Student Question S. I'm not sure about how the voltage can be measured (somewhat mumbled and unclear)

T. Well, if you like, go back to the stage where we remove the external circuit i.e. open the key - there are two ways, one I can't really explain unless you do physics - the way in which you use a Wheatstone Bridge which balances one er voltage against another and it does it by BALANCING and I assure you it can do that, modern voltmeters however, you can get them with very high internal resistance - in other words they take only a minute amount of current - now it is an approximation - if you put it across there for all intents and purposes the minute amount of current it takes is NEGLIGIBLE - so you get a very good approximate value for potential difference. I know people don't like approximates - and negligibles and things like that but that is what is done - mathematically you can show, using Ohm's law, y'know, that a drop in voltage by using such a voltmeter is very VERY small.
O.K. (S. nods) Anybody else?

(pause) No - O.K. There is in fact a notation which we use to describe such cells - Cell Diagrams - electrochemical cells can be represented by an internationally agreed system - for example for the Daniell cell - underneath your diagram it says (writes on board) - now that is how we describe that cell, we don't bother to draw out the whole cell, we write that down - that is the shorthand version - now - lets explain what it all means. - Now first of all will you look, you'll see there are 2 solid vertical lines - now what do they represent in my diagram - well they represent the boundary between the solid metal and the metal ions in solution - solid metals and ions in solution, difference between solid and liquid, solid and liquid, - so where it says 'solid vertical lines' will you write 'phase boundary' (B/B) i.e. in this case a solid and solution ...... I'm telling you a solid vertical line represents the boundary between 2 different phases - in this case a solid and a liquid. (pause)
Asks question of students.

What does the dotted vertical line represent in this case.

S. The porous pot.

T. Yeh, the porous pot - the boundary between the two solutions - for that then, the dotted vertical line we write (B/B) 'porous partition' or will you write 'salt bridge' (B/B) brackets see later - there is another device, rather than the porous pot, which we can use called a SALT BRIDGE.

Now, I've written that down and at the end we've written E is equal to - 1.1 volts right, E. on the next line, say E is the emf of the cell in volts (dictates) - now ......

Dictate

for some reason I have written it as MINUS one, 1.1 volts, as opposed to PLUS 1.1 volts - and the reason why we've done that - coming back to copper and zinc - which side was the negative electrode?

Notes possible problem areas

Question to students.

S's Zinc.

T. The zinc ...... the rule is whichever way we write our cell - whichever electrode ends up on the right hand side - next to the E value - then we use a sign to denote its polarity - so we write a minus here because the zinc electrode is the negative electrode - so no. 4. (B/B and dictation)

Uses answer to explain notation.
"the sign of $E$, plus or minus, indicates the polarity of the right hand - electrode"

"Brackets" - "as the cell is written".

(Long pause) Alright?

Student question S. So you always put the solution which is in the porous pot on the right?

Teacher uses Question and Answer to stress a point T. No, because soon we will discard porous pots and put salt bridges, you can - it doesn't matter which way round you write it you use the appropriate sign for the voltage -
Class Mr. A.

T. ...... ehm - sort of thing I mean here - suppose you have this set up (B/B) there's your metal rod dipping into the solution and so on - and we then connect a circuit from there to there, as soon as you do that you're introducing another metal into this solution - connecting wire and therefore it will set up its own electrode potential - so what the voltmeter will register is not the pure absolute electrode potential of this little rod, but it would be the difference between the electrode potential of that wire, whatever it is, copper wire, iron wire or whatever - is that idea O.K.

S. Would it apply with a carbon rod?

T. Well, this is a question - I know carbon doesn't form ions as such but you'll still get a potential difference set up due to absorption etc., so the answer is yes - its a good question though, right now - e thetas are therefore measured on a relative basis against a REFERENCE standard and the one chosen is the hydrogen electrode - shock!
horror! ....... you take a lot of hydrogen and you stick it in solution as a rod - (laughter from the students) - well - I will draw the hydrogen electrode for you and what we are saying is then that we use two electrodes in a cell-type arrangement - just as the Daniell cell was - and we use the same reference electrode each time - it is a hydrogen electrode and we compare the voltage set up against the various sets of metals - O.K. - right - so we've got a hydrogen electrode - could you draw something like this please. (draws on B/B - students copy down) (long pause) Now all I'm trying to show here - I'm not very good at drawing, if you have got a glass tube, the bottom is expanded into a bell-shape is perforated, i.e. there are gaps in the walls through which hydrogen gas can escape and bubble up to the surface ....... O.K. - and essentially what you do is to introduce hydrogen into this tube - now - we did say earlier on that concentration was important - well when we're dealing with hydrogen or any gas then we make the
condition that it must be at 1 atmosphere pressure. The solution that the electrode dips into is 1 molar with respect to hydrogen gas into one molar hydrogen ions. There will only be a very slow reaction to set up equilibrium and therefore we have to use a catalyst, this is the square section at the bottom - that in fact is a PLATINUM BLACK ELECTRODE - a catalyst. (Long pause while students label diagram). All right - leave it there - can I just talk about it now - this in fact - well, there is a fundamental error in my diagram - it can't possibly be like that - if I've got hydrogen gas coming in at one atmosphere - what about the level of the liquid.

S. They should both be the same.

T. Yes, it shouldn't BE lower in the tube but this is the normal way they represent it - I suppose what it means is if you push hydrogen in at one atmosphere, actually the perforations must be closer to the surface and bubbles will come out more or less at the surface - do you understand that point - if it is only at 1 atmos. then I shouldn't be
able to displace the liquid level down - but this is the normal accepted way of sketching the hydrogen electrode - so instead of a rod of hydrogen I've got a tube of hydrogen gas and I want to get in contact with hydrogen ions - making sure that they are 1 molar and it is at 25°C - now - let's have a look at the notes down below the space. "This electrode consists of hydrogen gas at one atmosphere in contact with 1 molar solution of its own ions at 25°C." Right "the platinum black electrode enables electrons to enter or leave the system and also catalyses the attainment of equilibrium between the hydrogen ions and the hydrogen" - now - em platinum black - I'll just explain - does anyone know what I mean by platinum black - you've come across a similar sort of idea when we talked about the silver mirror test - possibly you observed it in practice when you did you aldehyde and ketone tests - silver is normally a nice shiny normal metal BUT if its precipitated

S. Its finely divided.
T. That's right George, if it's precipitated out in a finely divided form — with a large surface area therefore — it appears as a black powder — now platinum black is the same — it is finely precipitated platinum and the reason we use it is because it is better than just shiny platinum because it has an immense surface area, being small particles, and therefore it's a SURFACE CATALYST, and what it does is it ADSORBS (B/B) i.e. it attracts hydrogen gas on its surface and at the same time it is surrounded by aqueous hydrogen ions, so that the hydrogen gas and the hydrogen ions can get into contact with each other — you are actually concentrating up the hydrogen molecules by the process, and the equilibrium will be set up — alright? Now 2 points, I'm saying that this equilibrium is set up if we bubble hydrogen in and its absorbed on to the platinum black surface — it will come into contact with hydrogen ions and you'd get this redox equilibrium set up ...... O.K. ...... now the second point is — we are using this as our reference electrode and we are going to
compare all our systems against it—all the other systems more able to release electrons or less able to release electrons so we are giving it an ARBITRARY value of zero—O.K.—ehm....... an analogy here—in geography or whatever we take sea level as being zero feet—which is fine if you are flying around in an airplane near the coast—you are going to be interested to know if the cliffs are 400 feet high, so you can keep your altitude...... if you are flying over a large plateau you're not very interested in how high the cliffs are—but, how high you are above that original 400 feet you are interested you. ...... Its all relative thats what I'm saying—another analogy I use—which usually gets me into trouble—I say—suppose we lost all the measuring devices in the world and we wanted to work out who was tall and who was short in this room—so we could choose someone as an arbitrary zero—well, I wouldn't choose G. (student about 6'4") because he's at one end of the scale.

S. You could do.

T. I could do yeh, true, but then everyone then would be short compared to my arbitrary
standard — now I can't think what you look like when you're standing up ...... all right we'll take him as our arbitrary average height — anyone above his height is tall, anyone below his height is short — ehm — one year I said something like ...... we should choose someone around 5'6" cos there won't be anyone less that 5 foot except for malignant dwarfs and one of the girls burst into tears (class laughter) I'll never do that again — but you get the idea — we'er just saying — let it be zero volts — we will compare all other systems against it — is that O.K.?

Why the heck they chose hydrogen I don't know — I don't know the historical background — all I can say is around the world in various laboratories — it is relatively easy to produce hydrogen in a pure form — it is relatively easy to pump it through a glass tube at 1 atmosphere and to get 1 molar acid so you can get up a standard reference electrode without too much trouble — O.K. — whether that is the reason I don't know — it may be tied up with the fact that hydrogen ions are in acids and we are very much
interested in reactions between acids, or hydrogen ions, and metals. ...... I'm not sure historically.

S. What was this bit about enables electrons to enter and leave the system.

T. Well, all I'm saying is - well - for example, if we just pump hydrogen gas through hydrogen ions solutions - we've got no connection with the outer world - no external circuit involved - so this electrode is my connection to my voltmeter - connects to the outer circuit ...... thats all it means - O.K. - I've got to have some sort of metal conducting substance in the solution to enable electrons to possibly be removed from that solution - if the system moves in that direction (refers to diag on B/B) I will create a source of electrons and they will be carried away through the back by copper wire.
APPENDIX IIc Part I.

PLOT OF LESSON - MR. A. CASE STUDY

LESSON UNITS

COMPONIION OF UNITS

- Check General Student Understanding
- Manipulative Analogs, Diagrams, and Experiments
- Demonstrate Previous Knowledge
- Hints for Memory or Problem
- Utile, Another Concept, Subject or Other Subject
- Reference to Practical Use
- Jokes
- Breaks or Digressions
- Rest or Break
- Exploration of Concepts
- Summaries or Generalizations
- Formal Language (Definition or Explanation)
- Student Data Questions
- Question and Answer Station for Q&A
APPENDIX IID

Atoms are spheres, I see the nucleus as a sphere but with all the different electrons I don't really see the whole atom as a sphere if taken individually. Mind when considering bonding don't see it myself. Not heard of it but can see it immediately. The solar system atom, the electrons orbiting a central nucleus.

Electrons live in shells, fine.

Electrons take up different energy levels, fine.

An electron cloud, I only really consider this with dipoles, delocalisation. Normally I see them as discrete, discrete, particles. Don't understand.

Electrons as pairs rather than scattered buckshot.

Yes, I see them as pairs from as in boxes but they like buckshot in the cloud density idea.

Imagine standing on the nucleus looking out at the electrons. I have never imagined doing such a thing.

You've got to do a lot of hard work to take off 4 electrons, yes, I like the nuclear attractions, shielding and atomic nuclei ideas.

What the atom will do is a question of balancing the losses and gains at the end of the day. Doesn't mean anything to me.

Use distance from nucleus for energy levels, yes, but then I don't like that and us switch over.

The parent atom of ions, like Fe is the parent of Fe²⁺, Fe³⁺?

Different types of species of ions, doesn't mean +ve or -ve ions.
'skeletons of molecules' liked it but kept falling into the trap of including any long ruts as branches as well.

'in a hydrogen molecule, each nucleus is in the middle of a tug-of-war in which none of the forces wins out so it is kept in a fixed position by the overall effect' But they vibrate & spin etc. One minor reason why hydrogen is so ideal, not all is translational energy.

'polarisation - British Rail and A.S.E.L.F. or politicians talking about their views' Never heard it but I like the political learning idea. Good opening for lively discussion which makes it memorable. When the reaction has been initiated, just like in the potting shed you get propagation. Sounds like an extract from 'Janet & John'.

'a never-ending cyclic process - a hole in my bucket situation' like it does never never heard it before.

'you cannot envisage doing a simple experiment which would give a direct answer for the enthalpy change so go around the houses and do two experiments' 'I altered the simple case of Hess' law.

'some chemicals you have to push up to the top of the hill before they will roll down the other side and give off energy' fits in nicely with a 'humpy' EI graphs. Not heard it before. 'isomerism pokes up its ugly multiple head' Not so much of the ugly. I think isomerism is fun, it could put people off.

'to him who hath shall be given' Gold Star award for Markovniko idea.

'if you have got a thick branch and you want to cut it; you improve your chances of cutting it by bending it, putting it under strain - it cuts more easily - the same applies to bonds' I think I've heard this before. It's quite clear anyway.

'dynamic equilibrium - running up a down-escalator' New one but a good phrase. Lots of it work going on but outwardly nothing. 'equilibrium is a rugby scrum - if I decrease the concentration of reactant on the left it is parallel to kicking someone in the groin before you have a push-over try' Clear & to the point. He is a 1/4 of the game so excusable.

'disordered chemicals made up in to the order of the systems etc in man and then he dies and goes back, breaks down into all the chemical bits and pieces' Had to read it three times to understand it.
level analogies that I am familiar with inclu-
sing the gate "when lighting a Bunsen to prevent the
g (who I guess was vicious) escaping." I still on the
left theme the story of the cat. The owners go out for
the day i leave the cat a saucer of milk. They come
back to find the saucer empty so think the cat is well
satisfied not realizing that the poor thing is starv-
ing but having been a sunny day all the milk molec-
ules were sipping in the saucer. It was a beginning discussion on rates.
'atoms are spheres' \(\checkmark\) This is true. I've been taught throughout school.

'described general shape.'

'the nucleus is where the pips would be in an apple.' \(\times\) Is never heard of it.

'the solar system atom, the electrons orbiting a central nucleus' \(\checkmark\) Hard to think of.

'electrons live in shells' \(\times\) Electrons are not alive, and description useless.

'electrons take up different energy levels' \(\checkmark\) Good description.

'an electron cloud' \(\checkmark\) Implicates the indeterminacy of electron no.

'an envelope of probability' \(\times\) Never heard of it.

'electrons as pairs rather than scattered buckshot' \(\times\) Never heard of it.

'imagine standing on the nucleus looking out at the electrons' \(\times\) Never heard of it.

'you've got to do a lot of hard work to take off 4 electrons' \(\checkmark\) And a good analogy for ionization and

'what the atom will do is a question of balancing the losses and gains at the end of the day' \(\times\) Does not like it. Very unclear.

'use distance from nucleus for energy levels' \(\checkmark\) This is true. Could be.

'the parent atom of ions' \(\checkmark\) Obvious, since a consequence of energy loss.

'must have come from an atom.'

'different types of species of ions' \(\checkmark\) Obvious.
'skeletons of molecules' / Heard of it. Like it. It attempts to explain the basic shape of the molecule in terms of its constituent molecular structure.

In a hydrogen molecule, each nucleus is in the middle of a tug-of-war in which none of the forces wins out so it is kept in a fixed position by the overall effect. It seems to be a reasonable explanation. I like it.

'polarisation - British Rail and A.S.E.L.F. or politicians talking about their views' / Haven't heard of it. Assuming there is a thing like it. But what is it? What is its function? Or its justification?

When the reaction has been initiated, just like in the potting shed you get propagation! Good. From one place you get many new molecules (or at least sub-units) and shoots. Likewise, one reaction molecule gives rise to many more reactions.

A never-ending cyclic process - a hole in my bucket situation! OK, but one aspect is that it implies that nothing is ever obsolete. More in fact, products are obtained.

You cannot envisage doing a simple experiment which would give a direct answer for the enthalpy change so go around the houses and do two experiments! Agree with doing 2 steps but do not think they go round the houses. Explanation: I agree with what it says.

'Some chemicals you have to push up to the top of the hill before they will roll down the other side and give off energy'

Never heard of it.

'Isomatism pokes up its ugly multiple head' /

Impurities sometimes in a mixture 'nasty'. I don't think it.

'To him who hath shall be given' / Markowitz's rule. Good explanation once you know what it is about, it is obvious.

'If you have got a thick branch and you want to cut it, you improve your chances of cutting it by bending it, putting it under strain - it cuts more easily - the same applies to bonds' / This is true and a very descriptive.

'Dynamic equilibrium - running up a down-escalator' / Very appropriate.

'Equilibrium is a rugby scrum - if I decrease the concentration of reactant on the left it is parallel to kicking someone in the groin before you have a push-over try!' Good. Implications must be opposite at present. It is obviously.

'Disordered chemicals made up in to the order of the systems etc in man and then he dies and goes back, breaks down into all the chemical bits and pieces' / Don't like it. Unless without.
I found thermochromy quite useful. I found especially difficult the concept of lattice energy. This is the energy released when ions of differing charges come together.

A way I tried to remember it was that a cowboy and an Indian come up to one another and shake the air hell out of each other.

How appropriate this is to the concept of lattice energy is very subjective, but it helps me.

I think this would work because we have been brought up in situations accepting that cowboys hate Indians (or vice versa) and so the cowboy could represent the positive ion, the Indian could represent the negative ion and their ensuing fight could represent the released energy.

My favorite metaphor is one concerning kinetistics.

If there was a team of 4 sprinters, me and 3 Olympic 100 metre champions, I would be the one who shared the overall team performance. If one of the 100 metre champions was slow, for a 200 metre champion, this would not increase appreciably the overall team reaching because I could still be the slowest.

In this analogy I represent the slow stage of the reaction, that is, no matter how much the fast stages are changed, their overall rate of the reaction will not increase because of a rate limiting stage, i.e., me.

I like this analogy because it helps me to remember the stages of kinetic reactions and also helps me to work out rate mechanism.
### Preliminary Analysis

Uses this reaction to introduce term.

(5) "substitution" only briefly referred to before.

A substitution reaction - a fairly simple term - is where you substitute an atom or group of atoms by another atom - or group of atoms - you can call it replacement as well. This is a model of the methane molecule then (shows it around class) if I make a model of chlorine as well (pause) then essentially as far as the methane molecule's concerned what you do is you take off one of the hydrogens (demonstrates) and stick a chlorine on its place so that you get THAT - and that leaves you with a hydrogen and chlorine left over - so you get HCl as well - but as far as THIS is concerned, as far as this molecule (methane) is concerned, what you have essentially done is you've started off with a hydrogen and you've simply replaced it with a chlorine atom and that's all that a substitution reaction really is so as an example of a substitution reaction really is so as an example of a substitution reaction we can say this (B/B) (repeats) "A substitution reaction

### Appendix III (a)

Anyway, this is an example of SUBSTITUTION reaction - em, I did just briefly mention last week that substitution reactions were just one of a number of classes of reaction that takes place in organic chemistry and I said that its quite useful to classify reactions according to type.

(6) Gives definition in simple English.

(7) Demonstrates simple example of process with ball and stick model.

(8) Gives formal definition - B/B
is one in which one atom or group of atoms is replaced by another atom or group of atoms. This is a very simple example of a substitution reaction in as much as just one atom - replaces another atom - we could actually go through the chemistry of a series of compounds - and find that its actually a quite common situation to have a larger group of atoms being replaced by another group of atoms - so what we are looking at is the simplest case. (pause)

Can you suggest what should be the name of that compound by the way (pause)  
Chloromethane. (T)

Yes, chloromethane - so that in the same way as we - ehm - had things like 2,2 dimethyl propane - we put the name of the group and then the name of the parent alkane, you can use the same sort of arrangement for that, so that compound CH3Cl is chloromethane - that can undergo further substitution - so you need a further Cl2 (B/B) that can then give us - any suggestions about what that might give us - yes.

Dichloroethane. (S)

Ah, now that would require growth wouldn't it in terms of the number of carbon atoms - so it can't be an ethane - its got to stick to a methane - if you get further substitution which is
what I said could happen, if you imagine
another hydrogen being replaced by another
chlorine - so that (demos with model) would be
the result of further substitution - where you
have replaced 2 of the hydrogen atoms by chlorine
atoms ........ what would you call that one?

Elicits correct
answer to
original Q.

S. Dichloro methane.
T. Good, dichloro methane - so you can write it down
like this (does equation on B/B) - so what's the
other product of the reaction going to be?

HCl.
HCl again because you've replaced one of the
hydrogens from here - so you've got a hydrogen
atom and then there's the second chloridne from
the chlorine molecule so you'd have to have HCl
again. (pause - students write equation).
And then if you've got another chlorine molecule
then you can get similar reaction producing -
(uses model to demo again) if you replace yet
another hydrogen by chlorine - you don't want
me to write it all up again do you (students
shake heads) so that gives you (B/B) "CHCl3" -
further substitution - name?

S's. Trichloro methane.
T. Good, does anyone know the trivial name for
trichloromethane?
S. T.C.P.
hand end - so you get HBr if you replace a centre one you get THIS and HBr. To some extent how much of each you get is dependent - is determined by the CHANCES of replacing an end one against the chances of replacing a middle one - which in turn is going to be partly dependent on the relative numbers of end ones and middle ones - so the first one is (B/B) "1 bromopropane" and the other is (B/B) "2 bromopropane".

Do they both have the same properties?

More or less - we'll come on to looking at the reactions of pairs of compound like that when we're looking at halogen compounds. In many of their reactions - yes - but there are slight differences - differences in rate of reaction and things like that. Any other questions (pause). This sort of reaction is limited if you're interested in PREPARING a particular compound - in that it does give you a random mixture of products which you then have to go to some lengths to separate out - all will have different boiling points for example so you could separate them out by fractional distillation - but by and large if you're thinking in terms of manufacturing industry - all the reactions that you carry out in the lab - in order to make a specific compound, you don't
want a random mixture of products in industry, you want just a particular compound - so you'd use another method ...... so that's halogens reactions with alkanes (pause) ...... you can substitute in other ways. When I was doing my chemistry degree I got a job one summer working in a quality control laboratory in ah ...... what was it called ...... part of Reo Tinto Zinc which is a metal smelting company - it is interesting to see how chemical companies actually grow - they started off small with lead and zinc extracting them from ores but they realised that they were always sulphur containing so they had lots of sulphur compounds produced - mainly sulphur dioxide as a product of the smelting process and ...... you can't just pump it out into the atmosphere ...... people don't tend to like that very much. (students laugh) So they converted the sulphur dioxide to sulphur trioxide and converted that to sulphuric acid on the plant - so you start off with the smelter and then you end up with the contact process for making sulphuric acid on the same site and then they say what can we do with the side products - well, if we brought in some fluoride we could make some hydrogen fluoride - that would be quite a profitable industrial chemical to make - so they make the hydrogen fluoride so they are now selling that to people -
so they then think ...... could we increase the value of our products by getting something in and making something out of the hydrogen fluoride so ...... they then bought in tetrachloromethane which they obtained from ...... er I can't remember ...... I.C.I. I think it was ...... who probably made it be the sort of route I showed and they then carried out a SUBSTITUTION reaction like this - this is not on the syllabus by the way so don't worry about it - its just interesting - so they carried out substitutions with that and you - first of all you get CFC13 (B/B) if you replace 1 chlorine with fluorine and then CF2C12 (B/B) (pause) ...... actually it should be the other way round CC13F + CC12F2 ...... we do it alphabetically - not thats the sort of thing thats used in aerosols - a propellant gas for hairsprays and the like. (pause) Anyway, CC14 can be made by substitution into propellant aerosol gases, some of the compounds are used for anaethetics - these are some of the uses for chlorinated and fluorinated compounds and I may say a bit more about that at a later date. (Cleans B/B) Now thats an important series of reactions which can occur with ALL alkanes - it is important to realise when we are going through organic chemistry that most reactions that you come across
are general reactions which apply to not just ONE compound but the whole series of compounds (pause) - Now, carrying on with the industrial side of things ...... "CRACKING" (B/B) cracking, anyone seen an advert for Texaco recently on television about the forefront of technology or something like that - we have just built for-I-don't-know-how-many millions a new CATCRACKER ...... (students laugh) anyone seen that advert? They don't mean they're breaking cats ...... that advert must have gone straight in one ear and out the other (more laughter) - its CAT short for catalytic cracker. A blooming great tower about 100 feet high that they stick things in while they - other things come out the other end. When I was talking the other day about chemicals (pause) and distillation of crude oils (puts OHP diagram up) one of the problems that the oil companies face is trying to match up the ...... materials that they get out of crude oil to the economic DEMAND for the materials ...... and the problem is of course that if ...... you produce - I don't know what the actual proportions are off hand ...... but say you only get 20% out of the crude oil as petrol - it may be lower than
that - but you would like to get or convert 50% of your crude oil to petrol then obviously you can't just simply separate crude oil, you've got to start doing chemical modification process in
APPENDIX Hic

PLOT OF LESSON - M. 13. - CASE STUDY 2

COMPOSITION OF UNIT

- Checks Understanding
- Jokes
- Breaks & Digression
- Anecdote
- Metaphors, Analogies
- Models/Diagrams
- New Information
  - Refers to practical
    - or everyday use
  - Refers to future use
  - Refers to old knowledge
- Student Question
- Teacher Question
- Repetition
- Formal Language

LESSON UNITS
Appendix IIIId

- 'atoms are spheres' (good) answers a 3D image - what sketches only 2D.

- 'the nucleus is where the pips would be in an apple' (good) - allows a visual image to be formed.

- 'the solar system atom, the electrons orbiting a central nucleus' - correct in some respects - electrons do not orbit the nucleus, can be at a good distance.

- 'electrons live in shells' (dislike) - type of shell could be easily confused.

- 'electrons take up different energy levels' (good) as far as it would like to be selected to be an everyday apple.

- 'an electron cloud' (good) again answers a 3D image.

- 'an envelope of probability' (dislike) - word probability when I meant probability calculations.

- 'electrons as pairs rather than scattered buckshot' (very good)

- 'imagine standing on the nucleus looking out at the electrons' (good)

- 'you've got to do a lot of hard work to take off 4 electrons' (good)

- 'what the atom will do is a question of balancing the losses and gains at the end of the day' (dislike) - wording confusing.

- 'use distance from nucleus for energy levels' (good)

- 'the parent atom of ions' (good)

- 'different types of species of ions' (dislike) - wording confusing.
'skeletons of molecules' rhomb (electrons absent)

'in a hydrogen molecule, each nucleus is in the middle of a tug-of-war in which none of the forces win out so it is kept in a fixed position by the overall effect' (Excellent) — immediately univocally and mind-bogglingly — good image aidfully.

'polarisation — British Rail and A.S.E.L.F. or politicians talking about their views' (Excellent) — provides a good analogy, as well as comedy.

'when the reaction has been initiated, just like in the potting shed you get propagation' (Good) — applicable mainly to chemistry students.

'a never-ending cyclic process — a hole in my bucket situation' OK, in this situation has to end in real life — confusing.

'you cannot envisage doing a simple experiment which would give a direct answer for the enthalpy change so go around the houses and do two experiments' (quite good) "you cannot ..." why?

'some chemicals you have to push up to the top of the hill before they will roll down the other side and give off energy' (Excellent) — can imagine this idea with ease.

'isomerism pokes up its ugly multiple head' (not very good) not a very good explanation — confusing.

'to him who hath shall be given' (dull) cannot see what it is in presenting or any uses.

'if you have got a thick branch and you want to cut it, you improve your chances of cutting it by bending it, putting it under strain — it cuts more easily — the same applies to bonds' (excellent)

'dynamic equilibrium — running up a down-escalator' (Excellent) — couldn't really grasp idea until now.

'equilibrium is a rugby scrum — if I decrease the concentration of reactant on the left it is parallel to kicking someone in the groin before you have a push-over try' (more understandable for boys who play rugby) OK, though.

'disordered chemicals made up in to the order of the systems etc in man and then he dies and goes back, breaks down into all the chemical bits and pieces'
Organic chemistry seems to me to consist of simply rules of different reactions which we acquire. Difficult catalysts and conditions I found an explanation as to why certain catalysts and conditions are used would help me remember about which products are the outcome of the reaction and why.

Shapes of electron clouds I find difficult to visualize and confusing to understand.

Favourite analogy

"O" level chemistry. To explain allotropics - you put an elastic band round a large No. of pencils. He showed that these could easily move over each other. However when a large pencil was put in they could not roll over each other so easily and were more likely to break or less likely to conduct electrons (the elastic band represented the electrons). The small pencils represented atoms of one kind and the large pencil the other.
'atoms are spheres' ✓
  could give impression of a solid ball ✓ be misleading
'the nucleus is where the pips would be in an apple' ✗
  could be confusing - have not heard
'the solar system atom, the electrons orbiting a central nucleus' ✓
  good if pips are not static have heard
'electrons live in shells' ✗ wrong impression gives the idea of
  sea shells ✓ energy levels - orbits
'electrons take up different energy levels' ✓
  true but could be dealt with differently
'an electron cloud' ✗ too abstract
  have heard
'an envelope of probability' ✗
  language not simple enough - never heard
'electrons as pairs rather than scattered buckshot' ✗
  gives a good idea have not heard
'imagine standing on the nucleus looking out at the electrons'
  could be a good idea in context
'you've got to do a lot of hard work to take off 4 electrons'
  good
'what the atom will do is a question of balancing the losses and gains
  at the end of the day' ✗
  good relates to other more day to day things
'use distance from nucleus for energy levels' ✗
  does not make sense
'the parent atom of ions' ✗
  don't understand
'different types of species of ions'
  very arbitrary
'skeletons of molecules'

don't like

'in a hydrogen molecule, each nucleus is in the middle of a tug-of-war in which none of the forces wins out so it is kept in a fixed position by the overall effect'.

like good analogy

'polarisation - British Rail and A.S.E.L.F. or politicians talking about their views'

don't like

'when the reaction has been initiated, just like in the potting shed you get propagation'

don't like

'a never-ending cyclic process - a hole in my bucket situation'

quite good but self explanatory

'you cannot envisage doing a simple experiment which would give a direct answer for the enthalpy change so go around the houses and do two experiments'

good but unnecessary. could just say do two exp. straight away.

'some chemicals you have to push up to the top of the hill before they will roll down the other side and give off energy'

good

'isomerism pokes up its ugly multiple head'

don't like - uncomfortably English

'to him who hath shall be given'

Yuk!

'if you have got a thick branch and you want to cut it, you improve your chances of cutting it by bending it, putting it under strain - it cuts more easily - the same applies to bonds'

good

'dynamic equilibrium - running up a down-escalator'

good

'equilibrium is a rugby scrum - if I decrease the concentration of reactant on the left it is parallel to kicking someone in the groin before you have a push-over try'

funny but you have to understand rugby

'disordered chemicals made up in to the order of the systems etc in man and then he dies and goes back, breaks down into all the chemical bits and pieces'
Something which has stuck in my mind from o'we was the first line we did something about redox reactions and this is.

**OIL** - oxidation is loss of e^{-}

**RIG** - reduction is gain of e^{-}

However this was all remembered and because I knew so little about redox reactions I could not use it. Therefore think it was a good way to remember what could be a confusing idea but perhaps if the rest of the topic was to try this sort of method I could have put it to use.

I thought it was a particularly good choice of words i.e. Oil Rig because they were also related as an object as well as an easy way of remembering two other related concepts.
<table>
<thead>
<tr>
<th>STUDENT</th>
<th>VIEWS ABOUT SCIENCE</th>
<th>VIEWS ON OWN LEARNING</th>
<th>VIEWS ON FIGURATIVE LANGUAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>N.C.</td>
<td>down-to-earth; logical; provides right answers</td>
<td>accepts what is offered, gains confidence from knowing more</td>
<td>It makes the abstract more pictorial. Builds confidence, helps interest and understanding.</td>
</tr>
<tr>
<td>G.T.</td>
<td>practical; related to life; provides answers</td>
<td>preference for practical aspects and broad overviews</td>
<td>Useful for initial idea, giving pictorial image; adds interest and amusement but can confuse.</td>
</tr>
<tr>
<td>M.D.</td>
<td>other sciences more practical; chemistry more a collection of rules to learn</td>
<td>has difficulty with rote-learning; needs to see sense and understand</td>
<td>Makes teacher seem more approachable; sustains interest and aids memory.</td>
</tr>
<tr>
<td>C.A.</td>
<td>chemistry too abstract and unproven - prefers things he can see</td>
<td>preference for physical proof as opposed to abstract theorising</td>
<td>Breaks monotony and helps memory.</td>
</tr>
<tr>
<td>A.B.</td>
<td>science is concerned with practicalities</td>
<td>preference for rote-learning, has difficulty with the abstract and theory</td>
<td>Relates to own experience, therefore is an aid to visualisation and memory.</td>
</tr>
<tr>
<td>R.S.</td>
<td>science is systematic and tangible. Likes proof to be presented</td>
<td>readily accepts wisdom from experts</td>
<td>Makes the abstract pictorial. Good for understanding, memory and interest.</td>
</tr>
<tr>
<td>K.L.</td>
<td>science is factual - the theory the most interesting</td>
<td>learning by rote is easy; conceptualising is difficult</td>
<td>Makes lessons amusing and aids memory.</td>
</tr>
<tr>
<td>TABLE II CO-ORDINATION OF DATA FROM ALL STUDENT INTERVIEWS</td>
<td>VIEWS ON FIGURATIVE LANGUAGE</td>
<td></td>
<td></td>
</tr>
<tr>
<td>----------------------------------------------------------</td>
<td>-------------------------------</td>
<td></td>
<td></td>
</tr>
<tr>
<td>STUDENT</td>
<td>VIEWS ABOUT SCIENCE</td>
<td>VIEWS ON LEARNING</td>
<td>Good for relating to and for forming pictures.</td>
</tr>
<tr>
<td>----------------</td>
<td>--------------------------------</td>
<td>----------------------------</td>
<td>---------------------------------------------</td>
</tr>
<tr>
<td>G.S.</td>
<td>science finds things out.</td>
<td>memorisation is difficult.</td>
<td>Relationship to the familiar helps memory. Humorous element sustains interest.</td>
</tr>
<tr>
<td></td>
<td>Chemistry deals with the more abstract issues</td>
<td>Understanding requires having something to relate to</td>
<td>Helpful for producing a pictorial image.</td>
</tr>
<tr>
<td>D.T.</td>
<td>science is theoretical with many laws to remember</td>
<td>dislikes role learning - prefers to understand what's happening</td>
<td></td>
</tr>
<tr>
<td>P.M.</td>
<td>science is theoretical and mathematical, has some laws and many hypotheses</td>
<td>dislikes mathematical aspect, needs demonstration and good explanation for understanding</td>
<td></td>
</tr>
<tr>
<td>M.S.</td>
<td>sciences overlap and have common vocabulary</td>
<td>prefers role learning, dislikes maths; finds it helpful if links can be made</td>
<td>Helps make sense of the abstract by providing a picture. Lightens lesson.</td>
</tr>
<tr>
<td>S.L.</td>
<td>science shows how things in the world work. Is a difficult subject; for clever people only</td>
<td>finds the pointing out of patterns and discussion with peers most helpful</td>
<td>Likes it as a basic explanation but likes to move on to more formal version</td>
</tr>
<tr>
<td>S.P.</td>
<td>science is related to the working of the world; still many unanswered questions in chemistry but many rules and laws in physics</td>
<td>helps if relationships are pointed out; needs variety in lesson; dislikes the predictable</td>
<td>Helps to think of the abstract in terms of solid things; helps to give a 3-D image.</td>
</tr>
<tr>
<td>N.W.</td>
<td>chemistry is fairly clear-cut, neat and orderly</td>
<td>practice and repetition in different ways is essential. Likes evidence and argument presented with facts</td>
<td></td>
</tr>
<tr>
<td>STUDENT</td>
<td>VIEWS ABOUT SCIENCE</td>
<td>VIEWS ON OWN LEARNING</td>
<td>VIEWS ON FIGURATIVE LANGUAGE</td>
</tr>
<tr>
<td>---------</td>
<td>------------------------------------------------------------------------------------</td>
<td>---------------------------------------------------------------------------------------</td>
<td>---------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>C.M.</td>
<td>chemistry is an orderly subject with laws</td>
<td>likes to be given a set of rules or formulae; understanding comes from working things out</td>
<td>Helps concentration because of the amusing element.</td>
</tr>
<tr>
<td>M.C.</td>
<td>physics is more an exact science than chemistry where many rules are frequently broken</td>
<td>likes proof and true facts, getting to the root of things</td>
<td>Helps with visualisation, memory and interest but too much would confuse.</td>
</tr>
<tr>
<td>S.H.</td>
<td>science sometimes divorced from reality; abstract concepts difficult to relate to real objects; needs a special kind of mind</td>
<td>rote learning is difficult; prefers to work out trends; likes to visualise what's happening to understand. Prefers concrete evidence</td>
<td>Good for giving something concrete to relate to - a picture to imagine. Helps learning to relate things to own experience.</td>
</tr>
<tr>
<td>F.A.</td>
<td>Not everything is known yet in science, laws only apply sometimes; chemistry concerned with composition, physics with behaviour</td>
<td>understanding principles is important. Helps understanding if a variety of explanations given from different perspectives</td>
<td>Help; prevent boredom; relating to common objects helps understanding; sometimes distracting; only good examples remembered.</td>
</tr>
<tr>
<td>R.J.</td>
<td>chemistry is to do with real life, physics is more abstract</td>
<td>prefers understanding to rote learning</td>
<td>Helps to form mental pictures of what is going on.</td>
</tr>
<tr>
<td>L.M.</td>
<td>science is the basis of everything that happens in the world, chemistry to do with understanding it</td>
<td>likes a good explanation and then to work on own. Too much maths confuses</td>
<td>Helps memory by relationship to the familiar; amusing and interesting.</td>
</tr>
<tr>
<td>P.F.</td>
<td>physics is more theoretical, chemistry more practical</td>
<td>needs to be able to ask questions and to discuss points</td>
<td>Good for forming mental pictures especially if related to the familiar. Also aids memory.</td>
</tr>
<tr>
<td>STUDENT</td>
<td>VIEWS ABOUT SCIENCE</td>
<td>VIEWS ON OWN LEARNING</td>
<td>VIEWS ON FIGURATIVE LANGUAGE</td>
</tr>
<tr>
<td>---------</td>
<td>---------------------</td>
<td>------------------------</td>
<td>----------------------------</td>
</tr>
<tr>
<td>M.W.</td>
<td>science is for intelligent people; chemistry is for finding out why things happen</td>
<td>understanding is very important, is dependent on the teacher and enjoyment.</td>
<td>Helps visualisation; likes relationship to the familiar.</td>
</tr>
<tr>
<td>S.I.</td>
<td>science is useful, practical and logical. Theories continually added to</td>
<td>cannot learn by rote; likes to work out a logical progression</td>
<td>Prefers straight facts to abstract ideas so concrete analogies help.</td>
</tr>
<tr>
<td>R.G.</td>
<td>chemistry concerned with the microscopic and ideas. Physics is more applied</td>
<td>understanding helped by a variety of presentation; basic ideas and arguments related into pattern</td>
<td>Understanding helped by relationship to familiar objects; humour helps memory and interest; help to build a 3-D mental image.</td>
</tr>
<tr>
<td>R.W.</td>
<td>science explains what happens and why and has practical application</td>
<td>maths means nothing to him; needs a 'story' and to be able to picture things</td>
<td>Provides a mental picture to refer back to later. Good for critical explanation.</td>
</tr>
<tr>
<td>S.H.</td>
<td>science is influential; prefers if provides definite proof but fascinated that some 'laws' might prove in error</td>
<td>learns better when lessons relaxed, question and argument allowed</td>
<td>Helps to provide visual image to relate to; to confirm own imagination of ideas. Good for memory.</td>
</tr>
<tr>
<td>S.A.</td>
<td>chemistry more practical, less abstract than physics</td>
<td>prefers activity in classroom to help attention. More interested when teacher is enthusiastic</td>
<td>Helps understanding by acting as a reference; helps give a 3-D image.</td>
</tr>
<tr>
<td>J.S.</td>
<td>mathematical and practical aspects the most interesting</td>
<td>prefers variety in lessons or working on own</td>
<td>Adds variety and interest but can be confusing.</td>
</tr>
<tr>
<td>STUDENT</td>
<td>VIEWS ABOUT SCIENCE</td>
<td>VIEWS ON OWN LEARNING</td>
<td>VIEWS ON FIGURATIVE LANGUAGE</td>
</tr>
<tr>
<td>---------</td>
<td>----------------------</td>
<td>-----------------------</td>
<td>-----------------------------</td>
</tr>
<tr>
<td>K.M.</td>
<td>chemistry related to life; and still has mysterious side; physics more tradition-bound</td>
<td>likes logical explanations, working things out on own. Teacher determines interest and enthusiasm</td>
<td>Essential for understanding, visualisation of the abstract. Helps memory and adds interest.</td>
</tr>
<tr>
<td>D.J.</td>
<td>physics is more theoretical; chemistry more practical</td>
<td>likes to work things out for himself</td>
<td>Helps memory of abstract concepts.</td>
</tr>
<tr>
<td>M.J.</td>
<td>chemistry has two aspects - theory and practice. The theory is abstract and frequently detached from physical evidence. Physics more concerned with visible things</td>
<td>rote learning is boring; putting theory to use is interesting</td>
<td>More interested in practical applications.</td>
</tr>
<tr>
<td>J.M.</td>
<td>science is the search for the truth about how things work</td>
<td>likes to find own solution and work out links, likes to see how everything fits in</td>
<td>Prefers logical descriptions but uses figurative descriptions.</td>
</tr>
<tr>
<td>N.T.</td>
<td>chemistry explains how things work and why - with technology has large practical value - is more predictive than physics, but changes with new information</td>
<td>likes playing with ideas, working things out, relating theory to common occurrences, discussing theory</td>
<td>Uses it all the time for understanding and memory.</td>
</tr>
<tr>
<td>M.R.</td>
<td>the abstract ideas in chemistry combine with visible principles in physics to produce practical results</td>
<td>likes to have something solid or visual to refer back to; likes to put theory to practical use</td>
<td>Mental picture produced can help understanding and memory.</td>
</tr>
</tbody>
</table>